Power and The Engineer

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A NUMBER of race horses are lined up before the barrier. One of them—and only one—will be the winner. All are as fit as their trainers possibly can make them.

The barrier is snapped up, the horses lunge into motion and the cry, "They're off!" announces that the race is on. The distance to be run is one and one-quarter miles.

The favorite, a famous "miler," takes the lead—his characteristic performance—and holds it until the seven-eighths pole is reached. Here, his right to the lead is challenged by two other horses. At the mile, all three are on even terms and each jockey "goes to the whip." Under the punishment of the lash one of the tired contenders swerves out and the cry goes up, "He's yellow!" The other contender gamely increases his speed and passes the favorite which, having run his distance, the mile, after a weak effort, quits in despair when the other horse passes him. A "long chance" has won.

The performances of these three animals are characteristic of three classes of men.

The favorite, which stopped at the end of his "distance," typifies that man who can do just so much and no more. In other words, the routine man. So long as he has a definite amount of work to do which requires only so much effort or initiative, this man gets along grandly. He does his "bit" willingly and well and is ready to go home when the whistle blows.

But, let an emergency arise when special effort is required or initiative action needed and this man thinks that he is "licked" before he even tries. And, like the horse, he "quits in despair" although, based on "past performance" and "form," he should win. Instead of saying "I will," he says "I can't." Having first convinced himself that he can't, it is small wonder that what feeble effort he does make is not crowned with success.

The horse which swerved to avoid the whip last symbolizes the human being whom we variously characterize as a "quitter," "sidestepper" or "fourflusher." Such a man deliberately tries to avoid his duty—to step from under, so to speak. He does not bother even to ask himself whether or not he should try to make good; he simply schemes to avoid being put to the test.

The winner represents the man who never admits that he is beaten, who battles on just as long as there is a single chance or scrap of hope left. Life teems with examples of success won by men who were badly handicapped.

Perseverance and bulldog grit explain their "luck."

The path to success is up a steep hill, laborious to climb. In places, the footholds are dangerously insecure. He who hesitates or is careless to make sure each step, often finds, all too late, that he is swiftly sliding back the distance which he had with great difficulty attained.

The adage, "All things come to him who waits," has long since been revised to, "All things come to him who *works* while he waits."

The Metropolitan Plant at Reading

By A. D. Blake

A central turbine station of 13,500 kilowatts capacity furnishing light and power to the city of Reading and the entire county of Berks. The equipment is uptodate in every respect and provision has been made to double the capacity of the plant.

The Metropolitan Electric Company, of Reading, Penn., besides furnishing electricity for the lighting, street railways and commercial power of that city, also supplies power, through high-voltage transmission and substations, to a number of constituent companies which serve practically the whole of Berks county.

Formerly the main generating station for this system was located at Seventh street in the heart of the city and consisted of four buildings which had been added from time to time. The total output of the plant was about 7000 horsepower, the equipment including units varying in capacity from 800 to 60 kilowatts, and in the first building there was a line shaft driving twenty Edison bipolar machines. With the enlargement of the system and the consequent increased demand for power the need of a new central station became imperative.

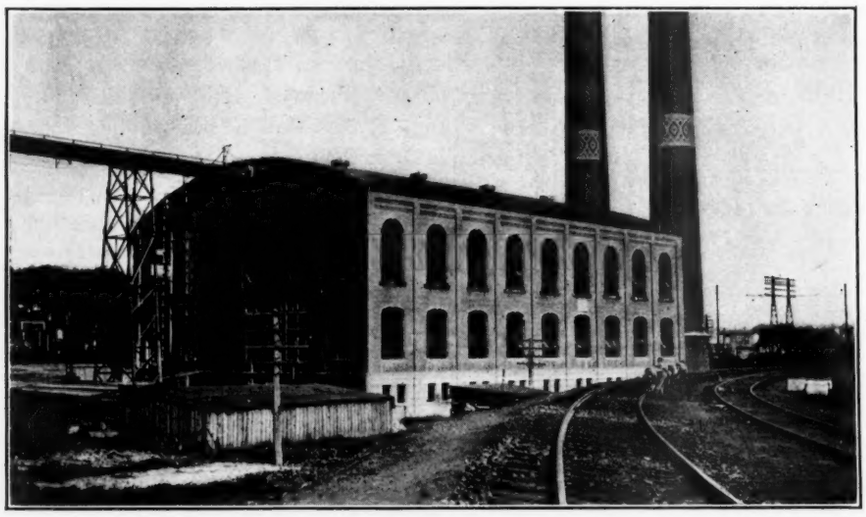


FIG. 1. EXTERIOR VIEW OF PLANT

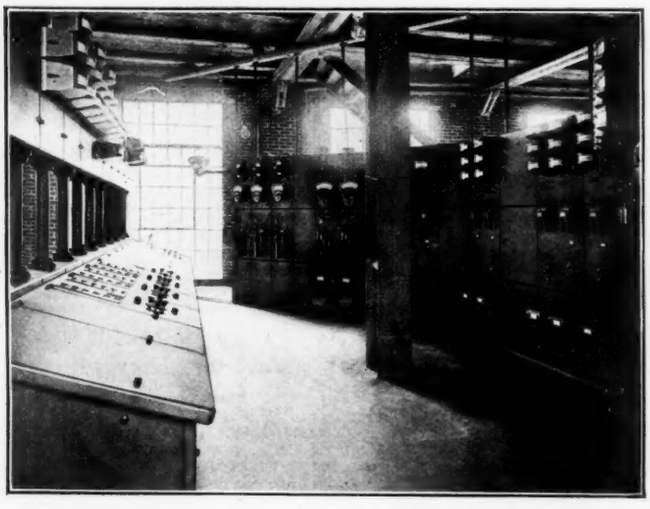


FIG. 2. SWITCHBOARDS

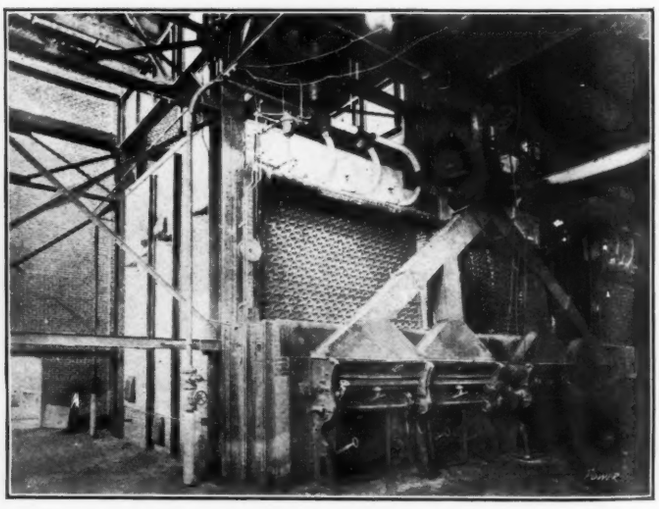


FIG. 3. FRONTS OF BOILERS

The new power house, an exterior view of which is shown in Fig. 1, is located on the outskirts of the city, a few hundred feet from the Schuylkill river, and at a point adjacent to two railroads; hence, the problem of coal delivery and circulating-water supply has been greatly simplified. The building is of steel framing with self-supporting brick walls resting on concrete basement walls, and has a curved roof consisting of supporting trusses carrying a 3-inch reinforced-concrete slab which is covered with three-ply roofing felt. Owing to the irregular geological formation the foundations rest partly upon rock, partly upon solid ground and partly upon piling. The building has been laid out with a view to future extension, the intention being to ultimately double its present size; hence all bays have been built alike and when finally completed the structure will be entirely symmetrical with another pair of chimneys at the far end. Owing to the prospect of an extension having to be made in the near future a sheet-metal wall, stamped to represent brick, has been placed at the extension end of the building. This is bolted to the framework in sections and can be removed and re-erected as often as desired.

Referring to the general plan, shown in Fig. 4, it will be seen that the main floor of the building proper is taken up by the boiler room and turbine room, separated by a dividing wall. The auxiliaries are located in the basement under the turbine room and the switching apparatus and substation are located in a wing structure; the latter expedient being made necessary by the shape of the available property. The basement floor is at a level which places it above all ordinary high-water marks of the river, but to protect the auxiliaries from any unusual spring freshets, the walls have been waterproofed to a hight of 8 feet from the floor.

Boiler Room and Coal-handling Outfit

There are sixteen 625-horsepower Edge Moor water-tube boilers set two in a battery and arranged in two rows. These furnish saturated steam to the turbines at 200 pounds gage. Two rectangular steel flues, one under each row, conduct the gases to two 242-foot radial brick stacks which are located outside the building.

Spurs from the railroads run over a track hopper which dumps direct to a crusher, from which the coal is carried on a 24-inch inclined belt conveyer to the power-house bunker. This bunker, which is of reinforced-concrete construction, has a capacity for 3900 tons. From the bunker the coal is delivered through chutes to the Wetzel automatic stokers with which the boilers are equipped. Each battery of boilers is supplied by one chute having a Y-connection and furnished with a weighing device. Fig. 3 is the front view of one of the boilers.

Ash hoppers are suspended from the floor beams under the boilers, and from these hoppers the ashes are dumped into motor cars (see Fig. 3) which convey them to a dump.

Main Generating Units

These consist of three 4500-kilowatt Allis-Chalmers turbo-generators running at 1800 revolutions per minute and delivering three-phase, 60-cycle, current at 13,200 volts. Each turbine has its individual oiling system consisting of a pump operated direct from the turbine and a supplementary steam-driven pump for use when starting up. Excitation current is furnished by two 100-kilowatt, 125-volt, horizontal units, each consisting of a General Electric Company generator driven by a Curtis turbine. A general view of the turbine room as seen from the switch gallery is shown in Fig. 6.

Auxiliaries

Each turbine exhausts into a Tomlinson barometric condenser located just back of the boilers. As will be seen by referring to Fig. 4 each condenser has two heads and two injection-water pipes. This arrangement was resorted to in order to avoid providing a greater clearance between the backs of the boilers and the wall, which would have been necessary with one large head. Each condenser is provided with its own circulating pump, which is of the centrifugal type driven by a 175-horsepower Kerr turbine, and by means of a main supply pipe and cutoff valves one pump may be made to supply another condenser if necessary. The circulating water is taken directly from the Schuylkill river through a 6x6-foot rectangular concrete flume running under the pump-room floor. On top of this is another flume of the same size into which the hotwells discharge through the openings in the foundation wall. The hotwells are placed so as not to be affected by any floods and this necessitated raising the exhaust-pipe connections above the condenser heads to the barometric distance above the possible high-water level.

The boiler feed water is taken from a dam in a creek at a point about a mile distant from the power house. The difference in head between these two points is so small that in order to make use of gravity it was necessary to avoid, as much as possible the loss in head due to pipe friction; this meant an unusually large supply pipe which would have entailed a great expense. Therefore, the pipe line was constructed of old boiler shells joined together by concrete. Three five-stage, turbine-driven Jeansville centrifugal pumps, each capable of delivering 700 gallons of water per minute at 260 pounds pressure, supply the boilers with feed water.

Advantage is taken of the fact that the Schuylkill river water is slightly acid, by providing connections whereby the boiler feed may be taken periodically from the circulating-water supply, thus

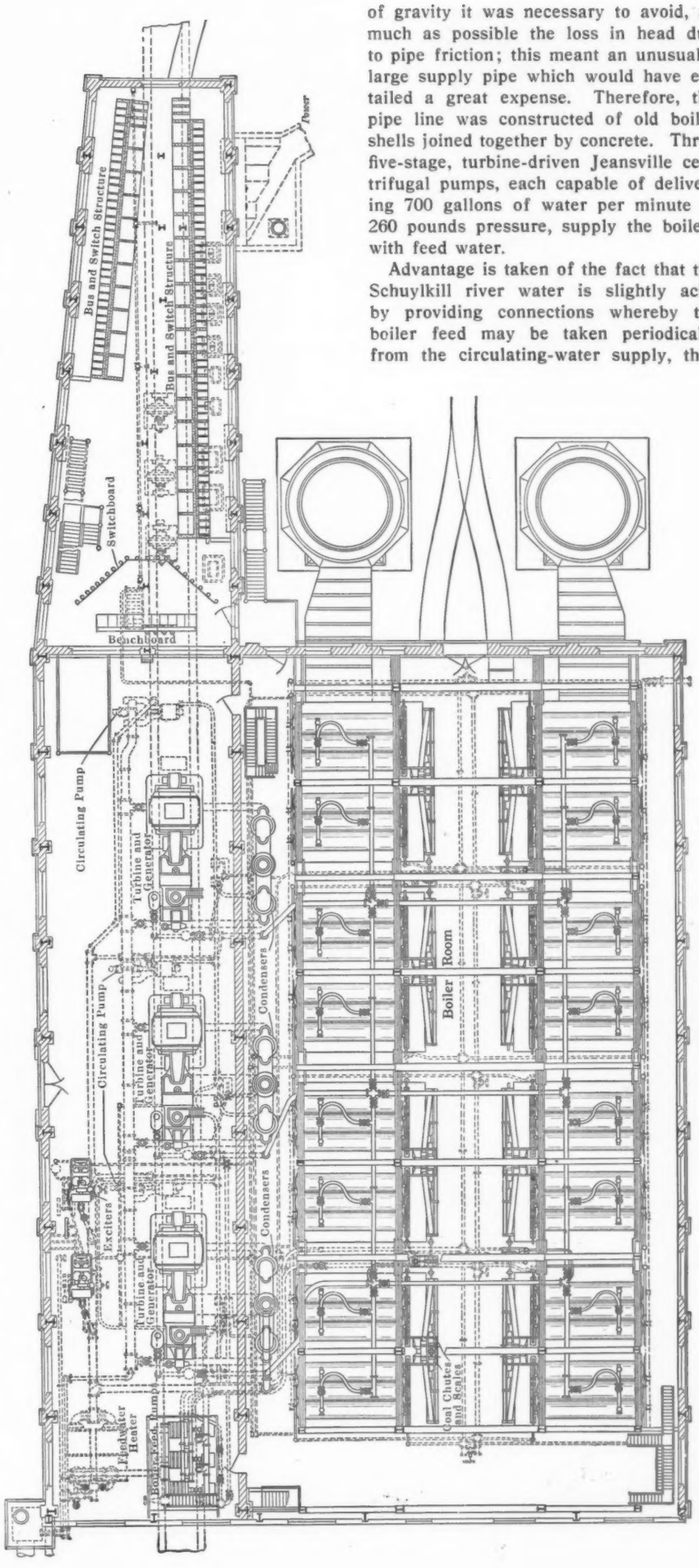


FIG. 4. GENERAL PLAN OF PLANT

neutralizing the action of the regular supply. So far, this has been found to work admirably in preventing scale.

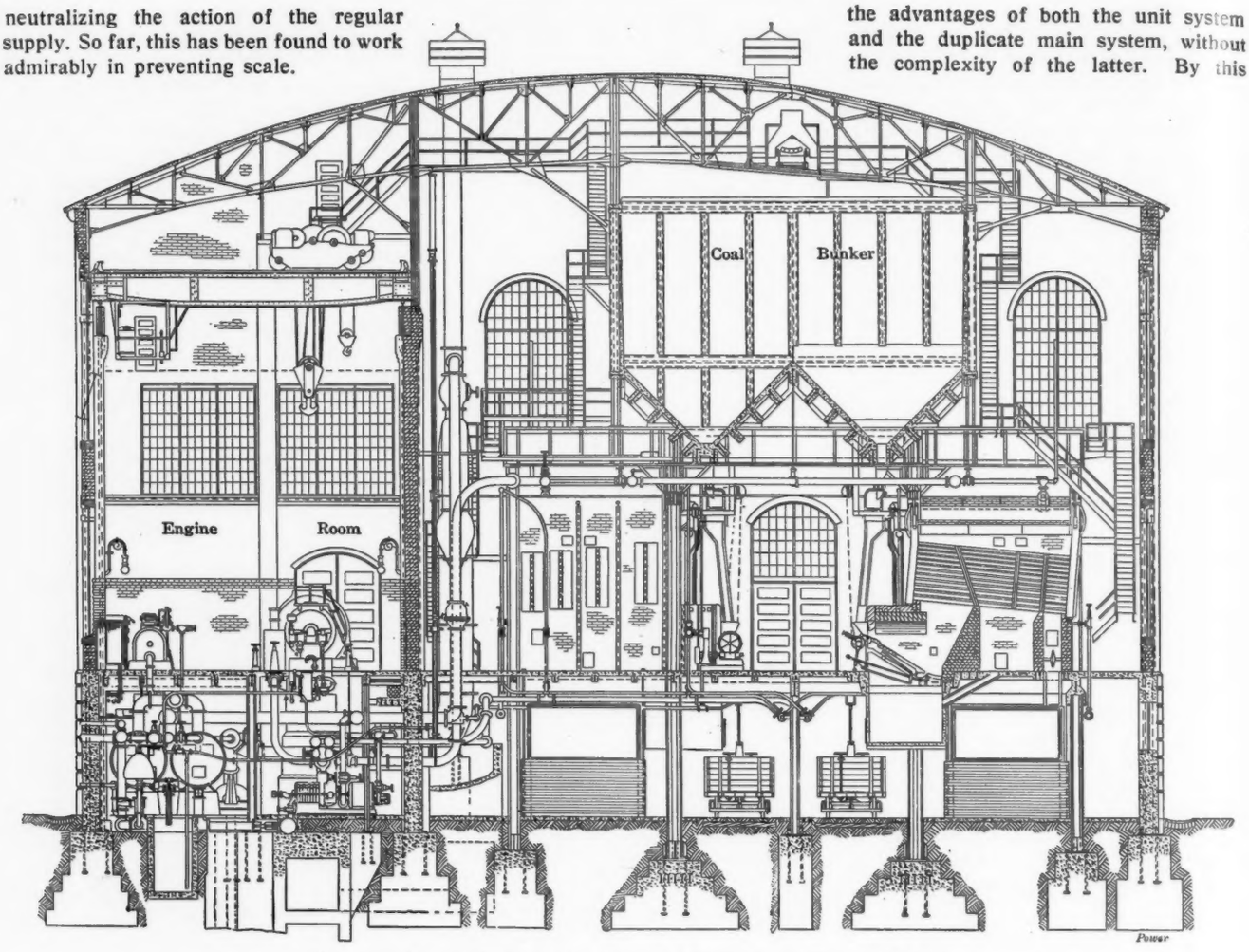


FIG. 5. ELEVATION THROUGH ENGINE AND BOILER ROOMS

The feed water is heated by two Cochrane heaters which utilize the exhaust steam from the auxiliaries.

PIPING

The main steam piping from the boilers to the turbines is laid out so that it has the advantages of both the unit system and the duplicate main system, without the complexity of the latter. By this arrangement it is always possible to have enough boilers connected to any one turbine, regardless of what boilers are out of commission. All expansion is taken up by long-radius bends and no piping is visible in the turbine room except the risers through the floor to the machines.

The feed lines from the pumps to the boilers consist of duplicate mains running the length of the boiler-room basement. Each boiler has a front connection to one of these mains and a rear connection to the other, thus insuring the feeding of any boiler should one of the mains or branch lines become disabled.

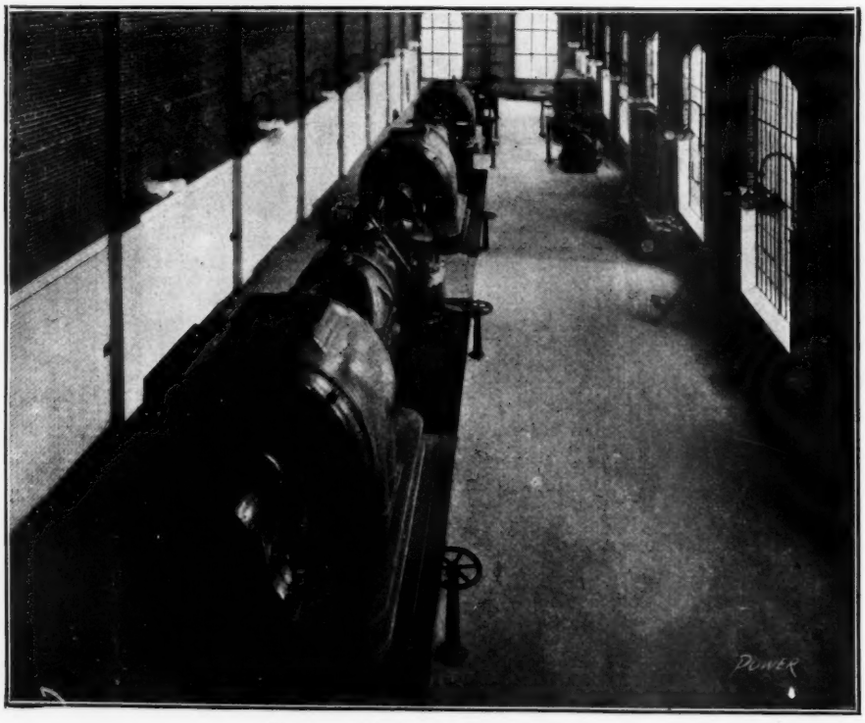


FIG. 6. VIEW OF TURBINE ROOM

ELECTRICAL EQUIPMENT

As previously stated, the electrical equipment, except the generators and exciters, is housed in the wing structure. On the first floor there are two 500-kilowatt Westinghouse railway rotaries, each supplied from a three-phase transformer, with provision made for a third rotary and transformer. Two small transformers supply current for the plant lighting and power.

On the second floor is located the high-tension switch and bus structure which is constructed of concrete throughout, excepting the floor slabs, and contains, in addition to the regular service and spare

switches, two sets of buses. The disconnecting switches are arranged so that either of these buses may be thrown out of circuit for repairs without interrupting the service.

On this floor is also located the feeder switchboard, containing the recording instruments and the remote control for the high-tension switches, and the bench board for the generator and exciter control. These are shown in Fig. 2. They face one another and are placed so that the switchboard operator may have an unobstructed view of the generator room at all times.

The lightning arresters, which are of the tank type, made by the General Electric Company, are located on the third floor.

The plant at present supplies six substations, in addition to a portable substation consisting of a 500-kilowatt rotary and transformer mounted on a car which may be run anywhere over the lines to handle an extra load or to temporarily take the place of any other substation that might be out of service for repairs or other reasons.

The largest of these substations is the old generating station at Seventh street. The greater part of the old equipment of this plant has been either sold or scrapped and the buildings are being renovated to make them more nearly fireproof. When the alterations have been effected this will be the main distributing station for handling the city load. This being on the opposite side of the river from the new power house, the high-tension cables are carried under the river in armored submarine cables and through underground ducts to the substation. The high-tension lines going to the other substations are carried partly on towers and partly on poles.

The entire plant was designed by and constructed under the supervision of Walter J. Jones, consulting engineer with offices in New York City.

Engineer's Problem in Selecting Coal

By George H. Bayne

In selecting coal, one is not concerned so much with the actual heat contents as with the ability of a certain coal to produce the greatest evaporation under the particular operating conditions. With this in view, directions are given for making standardization tests to determine the comparative evaporative efficiency of the various coals under consideration.

Rapidly increasing competition and the high cost of labor have made it necessary for manufacturers throughout this country to look most carefully into their operating expenses and cost of production. Having reduced to a minimum their expenses in the finishing rooms, sales departments and executive offices, and having installed elaborate systems for estimating and recording the cost of their output, they have now awakened to the fact that while they are giving strict and intelligent consideration to every phase of the economical manufacture of their product, they have neglected to consider seriously one of the most essential and fundamental points in their first cost; namely, the input of their coal and the economic distribution of their power as delivered to the factory from the boiler room. It is remarkable that in many large manufacturing concerns in this country, where every attention is given to systematizing and regulating the departments, very little, if any, consideration is given to the boiler room, in which may be wasted the most essential of our natural resources—coal—the economical consumption of which is one of the most vital questions in the generation of power. The first cost of the fuel, its adaptability to the furnace and economic firing by the fireman, in a great many instances, make or break competition and profits.

In the production of steam the first cost to the manufacturer arises; here his initial loss begins and here 50 per cent. of his expense is invested. Therefore, the question that confronts the wide-awake president or general manager of uptodate commercial industries is, how, under their present conditions, are they to increase the efficiency and at the same time reduce the cost of their power production. The answer to this question can be ascertained only by careful tests of the boiler plant under actual operating conditions; such tests to be conducted by a competent engineer, who will determine, practically and scientifically, what can be expected of the plant in conjunction with the different grades of fuel available in the market, also the most economical methods of firing and the cost of producing power under the existing conditions. When this is done, the manufacturer is confronted with the bare facts of having used so many pounds of coal and having produced so much measurable work. It then becomes a matter of simple arithmetic for him to establish a definite cost for his power production. This test, followed up by systematic daily reports from the boiler room, will give the operator such an understanding of the relative value of horsepower that it will enable him to locate the cause instantly, when excessive rates become apparent and the power department has passed the economical point. It then becomes the duty of every operating engineer to furnish such data as may be required for this purpose, and to familiarize himself with the practice and methods involved, wherein he can find out for himself just what his boiler room is doing. The engineer who produces the most power for the least money is invariably the man who is giving this question the most consideration.

In advancing a few suggestions on this topic the writer will confine the discussion to the testing of coal and boilers for establishing the rate for a boiler horsepower, and will endeavor to lay down a few essential rules whereby this rate can be ascertained without going into a long theoretical treatment.

The majority of manufacturing concerns have installed certain boilers and appliances which to the mind of the constructing engineer, at the time the plant was built, were best suited to the purposes for which they were designed. Owing to the cost of installation and so forth, it is, in most cases, up to the operating engineer to make the best of the installation as he finds it, although it might often prove more economical in the end for the concern by which he is employed to completely remodel the plant. Unfortunately, this is usually out of the question, owing to the necessary investment of extra capital; however, every plant has its gait and this gait can be found and the maximum point of economy determined. Whether the plant is hand fired, or mechanical stokers are used, or whether the steam producer is a horizontal return-tubular boiler or a water-tube boiler, etc., the engineer is given charge of the plant and is expected to produce the best possible results under the existing circumstances. This may or may not be true economy, but it is nevertheless a glaring fact which faces 80 per cent. of the stationary engineers. Again, it must be borne in mind that the purchasing of the fuel, in ninety-nine cases out of a hundred, is done by a purchasing agent whose business it is to buy coal as cheaply as possible, regardless of quality. It is usually not the fuel that gives the most heat per ton, but the coal that gives the most bulk per dollar that is turned over to the engineer for steam-producing purposes. This point often works a hardship on the en-

gineer and fireman and is one of the most vital questions of boiler-room economy, over which, unfortunately, the average engineer has no control. The writer thoroughly believes in the old adage that the proof of the pudding is in the eating, and that the man who controls the burning of the coal, and is responsible for it, should have a voice in determining which fuel, at the market price, is best adapted to his needs.

With these facts in mind assume, for example, a boiler room of three to five boilers, of either the water-tube or horizontal return-tubular type, hand fired, properly installed, equipped with the necessary auxiliaries, and in charge of a competent and wide-awake stationary engineer, a man of common sense, ability and experience in boiler-room practice. These are the first essentials of boiler-room economy. The next question to take up is the purchasing of fuel. This, as before mentioned, is generally done by the purchasing agent of the firm. To be able to produce the best results, this man should be in close touch with the engineer and they together should pass upon the choice of the fuel supply. The former is thoroughly in touch with the market conditions and with the different grades of fuel at his disposal; the latter, on the other hand, from his experience in burning various grades of coal, can supply the practical information as to which fuel is the best to be used under the particular conditions; but he can do this only after testing the several grades which are at the disposal of the purchasing agent.

The question of buying fuel on the heat-unit basis, or the B.t.u. specifications, has been so widely discussed and exploited of late that it is hardly necessary to go into the matter in detail; that the B.t.u. specifications have good points and that they also have limitations is conceded by all. Specifications of this nature, when in the hands of experts, are usually satisfactory to both consumer and seller, but otherwise the result is apt to be unsatisfactory to both parties. The wise purchasing agent, having classified the several grades of coal available in his territory, as far as prices are concerned, calls in the services of a competent engineering chemist, who analyzes the fuel and advises him as to its constituents. This, then, establishes a comparative standard of analysis for each of the grades of fuel and gives the buyer an insight into the quality of the commodity he is buying, besides establishing a basis upon which he can place his contract with the coal company supplying the fuel and thereby compel the shipper to furnish, during the life of that contract, a uniform quality of coal within reasonable limits. This is as far as the purchasing agent can go for the present and is only one-half the problem in the placing of his fuel contract. With this information in hand the purchasing agent orders sample cars of the several grades under consideration and turns them over to the operating engineer for practical tests, to determine which coal will work to the best advantage under his particular conditions. With the results of the tests, together with his knowledge of the fuel, the purchasing agent is in a position to place his contract to the best advantage and with precision, putting the responsibility upon the engineer to produce results.

This preliminary test by the engineer for the benefit of the purchasing agent is generally conducted in the following manner: One boiler in the line is designated for test purposes and is put in thorough repair; the boiler tubes are blown out and the combustion chambers and furnace are cleaned; the brickwork and settings are pointed up and made as tight as possible; the blowoff cocks are blanked off; the feed-water line is bypassed, so that this boiler can be fed separately, which is usually done by attaching the bypass to the emergency feed pump, with which all plants should be equipped, and by placing a meter in the feed line between the pump and boiler. A Worthington duplex piston meter or a Venturi meter should be used for this purpose, or the water may be weighed in barrels placed on scales. The latter method, although the most accurate, usually requires the attendance of an extra man and is frequently impracticable. It has been the writer's experience that when meter readings are taken with either of the above instruments, which should be calibrated before and after the test, that the results are sufficiently accurate and have the advantage of eliminating, to a large extent, the personal equation of the attendant. A thermometer for taking the feed-water temperature should be placed in the feed line as near as possible to the entrance of this line into the boiler. A pyrometer should be placed in the breeching between the damper and the boiler in order to take the temperature of the escaping gases. A hand-draft gage of the "U" type should be used to ascertain the draft over the fire, at the stack, and in the combustion chamber in the case of horizontal return-tubular boilers; if a water-tube boiler is being tested the draft is taken in the different passes and at the stack. A platform scales should be placed in the fire room and the coal under test is weighed upon them before delivering to the fireman. With this equipment in place, the engineer in charge is ready to proceed with the test and must bear in mind the following points:

1. That his object is to ascertain the commercial efficiency of the coal in question under the particular conditions, and that he is making a fuel test and not an elaborate boiler test with all its refinements.

2. That the value of this coal to him is just in proportion to the number of pounds of coal that he has to use to produce a boiler horsepower over a fixed period of time, and is in proportion to the number of pounds of water evaporated by the boiler over this period when reduced to an evaporation from and at 212 degrees Fahrenheit.

3. That to accomplish the best results he should place the boiler and furnace in charge of an experienced fireman and should personally supervise the taking of readings and the general method of firing throughout the test.

4. That he must keep a record of the initial and final readings of the meter (if one is used), the average pressure maintained by steam gage, the average temperature of the feed water, the average temperature of the escaping gases (by the pyrometer), the number of pounds of coal fired and the weight and nature of the ash and clinker taken from the furnace during the cleanings.

5. That this test should cover the usual factory day, either eight, ten or twenty-four hours, as the case may be.

6. That careful observations should be made at frequent intervals to see that there are no holes in the fire and that the fireman is doing his work properly.

The simplest method of starting a test is to have the fire completely cleaned out and a new fire started, and take note of the hight of the water in the gage; for a matter of convenience, a string may be tied around the gage showing the hight of the water column. This done, the test is ready to start, the feed water is turned on through the meter and the fireman begins to use the weighed coal, and continues to do so during the entire test. Care should be taken to keep the feed water as near as possible to the hight of the string on the gage. To close the test the water is brought back to the starting point on the gage and the fire is allowed to die down and, as soon as practicable, is cleaned. The total amount of refuse from the firebox and ashpit is removed and weighed on the scales, care being taken that the fireman is not permitted to wet down the resultant refuse, as is common practice, before it is weighed.

When these instructions have been carefully adhered to, the engineer has at his command all the necessary information to calculate the results. This process of testing is repeated for each grade of coal that is under consideration by the purchasing agent and each test should be conducted by the same man and fired by the same fireman. The results of these tests, when reduced to an evaporation from and at 212 degrees Fahrenheit and referred to the different costs per ton, will give the engineer and the purchasing agent a definite comparison of the commercial value to them of the respective fuels.

Installing Refrigerating System

By F. E. Matthews

Kind of pipe and fittings to use, how joints are made and leaks in the system detected and repaired.

A complete refrigerating system embraces a power plant with the usual details in addition to the several members included in the refrigerating system proper. The installation of the compressor requires little more care than that of the engines and boilers of a refrigerating or any other plant. It is scarcely necessary to state, however, that every detail connected with the installation of the piping of ammonia, or other refrigerable gases as a working medium should be executed with the greatest care. Only such materials as have been found by responsible builders to be well adapted to their respective purposes, should be employed. For ammonia, good full weight wrought-iron pipe is to be recommended for the expansion or low-pressure side, and extra-heavy pipe and ammonia fittings of approved design for piping the compression side.

In damp places, where the low-pressure gas headers are liable to rust abnormally, these also should be of extra-heavy pipe.

There is always a favorable opportunity for corrosion where pipes pass through cooler walls, it usually being practically impossible to make the insulation air tight at this point. If such parts are protected by a thick coat of asphaltic paint, or better, a double layer of canvas saturated with asphaltic paint or other waterproofing agents, it may save great annoyance and material expense in the years to come.

Making Joints

Ammonia pipe joints are usually made up with lead or rubber gaskets in male and female flanges, sweated on the pipes. Some builders employ a litharge and glycerin cement in making up screwed joints instead of solder, and there is little difficulty in making such joints tight if scrupulous care is exercised in seeing that only true, sharp, properly formed threads are used; that they are thoroughly cleaned, for which purpose gasolene is to be recommended; that the litharge is freshly and thoroughly mixed into a thin paste; and that the joints are made up tight.

It seems trite to suggest that gasket and flange joints should be drawn up squarely, but many a charge of ammonia has been lost through lack of attention to this detail. Rubber gaskets are particularly likely to blow out of improperly drawn up flanges months later when the rubber has had opportunity to be softened by oil. It can be most truly said that eternal vigilance in erection is the only price by which a permanently tight refrigerating system can be purchased.

When the erection of the plant is complete, and the piping thoroughly blown out to free it from dirt, scale, metallic chips and other foreign substances, an air pressure of not less than 300 pounds should be pumped on it to test for leaks.

Detecting Leaks

Leaks, such as split pipes and improperly made up gasket joints may be readily located by the sound. In fact, in a still cooler, sound is the most efficient means of detecting very small leaks even of ammonia, where the air has become so laden with the fumes to make the usual methods of testing difficult. When all of the leaks have apparently been stopped, it is advisable to pump a pressure on the piping and let it stand for ten or twelve hours. The drop in pressure, provided there is no appreciable change in temperature, will indicate the amount of leakage. As a final precaution the air may be allowed to escape and the system again charged with air into which a sufficient amount of ammonia has been fed to make any leak easily detected either by smell or by means of sulphur sticks.

Sulphur sticks used for testing for ammonia are made of pieces of white pine, or other wood which burns with little smoke, split into splinters about half the size of a lead pencil and from 6 to 8 inches long. These sticks are then dipped into molten sulphur so that about 4 inches of the ends are thoroughly coated, and after being cooled are ready for use. In testing for leaks, the sticks are ignited and held close to the suspected pipe or fitting. If there is escaping ammonia, it will, on coming in contact with the burning sulphur, produce a very noticeable white cloud. The approximate location having been found by means of the sulphur fumes, the exact position of the leak may be located by means of oil applied to the leak by means of a long-nosed oil can or soap suds applied with a brush.

Where there is a likelihood of existence of leaks in pipe or submerged condensers, or other places where escaping ammonia would not readily be detected because of its entering into solution in the cooling water or cooled brine as the case may be, it is advisable to test these liquids periodically with some reliable reagent. Where there are not too many foreign substances present, the litmus and turmeric papers are fairly reliable. A more satisfactory reagent, however, for use under the varied operating conditions of refrigerating and ice-making plants, is Nessler's solution, a few drops of which added to the suspected water or brine will show a yellow discoloration for slight traces of ammonia, increasing with the amount of ammonia present until with large quantities a reddish-brown precipitate is formed.

Repairing Leaks

Many small leaks such as occur in ammonia fittings may be stopped by the judicious use of a set of small calking tools.

Porous spots in iron and steel castings may sometimes be remedied by the judicious use of some rusting solution such as sal ammoniac or hydrochloric acid. Where the leaks are occasioned by blow holes of considerable size occurring where the application of pressure will tend to drive the substance into the porosities of the iron, some of the patented rust-joint preparations may be effective.

Troublesome leaks due to imperfect welds in the seams of pipes may be effectively repaired by first cleaning the pipe with a file and some suitable soldering solution, then applying a closely laid course of bright steel wire. The layer of wire should then be saturated with the soldering solution and the whole surface thoroughly coated with solder, special care being taken to see that it is thoroughly sweated in at the point where the leak occurs. The steel wire supplies the tensile strength, the lack of which in the solder would often allow the ammonia under pressure to lift off the solder coating. A hard solder should be employed and the steel wire should be thoroughly "tinned" to protect it from rust.

For soldering iron and steel pipes two soldering solutions should be employed, the first being simply a cleaning solution of concentrated hydrochloric acid, and the second a saturated solution of zinc chloride, commonly known among tinners as "cut acid." This second solution is prepared by dissolving metallic zinc in concentrated hydrochloric acid. Some builders add to the zinc chloride thus formed an equal amount of ammonium chloride.

Leaks, both in pipes and castings, may be repaired and separate pieces of pipe may be welded together to form continuous pipes, coils and headers, by means of improved processes of electric and oxyacetyline welding. Ammonia receivers, as well as larger shells such as are used for constructing absorbers, condensers and generators of absorption machines, are also made by this process.

Boiler Tube Brushes and Scrapers

By Warren O. Rogers

A stiff wire brush will clean a boiler tube if the deposit has not caked. A more effectual device is a combination of brush and scraper, the scraper loosening the soot and the brush removing it. A number of these types are described.

Although the improvements in tube scrapers have been marked, manufacturers have also improved the tube brush, and in several instances a combination tube brush and scraper has served to good purpose. The idea of making a combination device is due to the fact that as a general thing, a scraper will not push out all of the soot it detaches from the surface of the tube. The brush following the scraper blades not only brushes the soot loosened on the tube, but also cleans out the soot that sifts past the scraper blades. With a combination scraper a tube should be cleaned thoroughly.

An early type of wire brush used for brushing out soot is shown in Fig. 1. The brush is so constructed that the sections do not allow the open spaces between them to extend the whole length of the brush. Each section has an offset at the middle, as shown, so that the open space at one end is covered by the offset at the other end. This cleans the whole

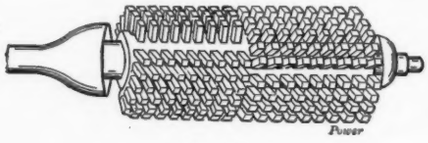


FIG. 1.

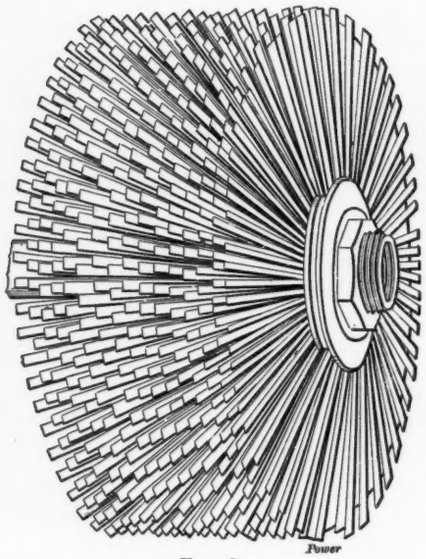


FIG. 2.

surface of the tube each time the brush is pushed through.

On the end of the brush is fitted a conical cap which not only protects the wire, but also allows the brush to easily slip back into the tube in case it is pushed entirely through. The brush is made of steel wire and malleable-iron castings.

Another make of tube brush is shown in Fig. 2. It is made of stiff steel wire set into a center piece, as shown. The size ranges from 2 to 20 inches in diameter, the latter size being illustrated. This brush is made by the J. W. Paxson Company.

A flue brush with an iron guard, made by the Pilley Packing and Flue Brush Manufacturing Company, and others, is shown in Fig. 3. It is made of steel and is built up on an iron casting having flanged ends, making it impossible for the brush to slip in the tube. The brush is easily brought back into the tube, in case it is pushed through at the rear end by the iron guards.

Another type of brush is shown in Fig. 4. It is rigid, and the wires are supported in iron rings which are clamped on the spindle. It is made by J. W. Paxson Company.

Fig. 5 illustrates a very durable brush.

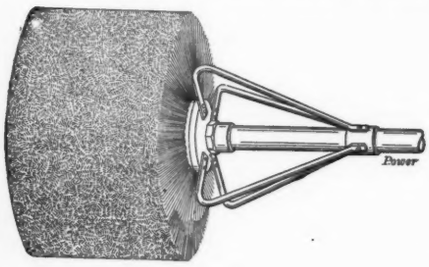


FIG. 3.

FIG. 4.

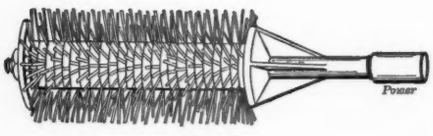


FIG. 5.

It is made of flat tempered-steel wire. The ends of the brush are protected by shields. It is made by A. W. Chesterton Company, which firm also makes a brush similar to that shown in Fig. 4.

The brush shown in Fig. 6 is made by Warren F. Flint. It is constructed of fine steel wire secured to a twisted central piece. One end is filled with a pipe section having a thread for connecting a handle. Another design, made by the same company, is shown in Fig. 7. This is a hard wire brush, the ends of which are protected by caps.

Still another brush tube cleaner is shown in Fig. 8. It consists of a brush composed of strong, flexible wire, which when pushed through the tube removes the soot from off the surface and pushes it out at the end.

Fig. 9 shows a design of brush made by F. N. Browne. It is constructed of

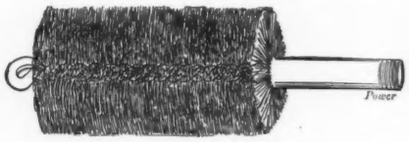


FIG. 6.

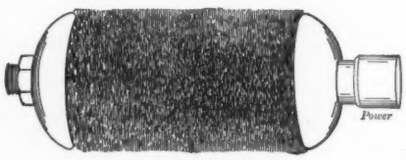


FIG. 7.

FIG. 8.

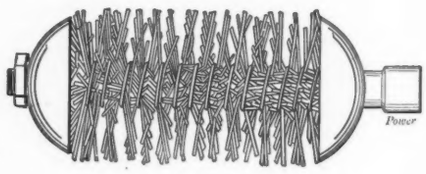


FIG. 9.

stiff steel wire and is fitted with a pipe connection for a handle attachment.

William Mulholland makes the brush shown in Fig. 10. Steel wire is used, and the brush is reinforced at one end by a cap which also serves as a receptacle for the handle.

Fig. 11 shows a design of flue brush made by several firms. It consists of steel wires secured to two wire rods, twisted as shown in the cut. The result is that the steel wire forming the brush takes a spiral form.

A combination brush and scraper is shown in Fig. 12. It is manufactured by James L. Robertson & Sons, and several other firms. The scraper section consists of scraping blades which readily conform to the opening in the tube, due to the joint construction. As the scraper

edges are forced in by the tube surface the spring is compressed, and as a result the scraper blades are forced against the tube by the action of the spring which is protected from heat and dirt by a casing. The brush removes the loosened soot.

The combination flue brush and

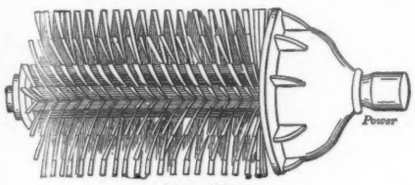


FIG. 10.

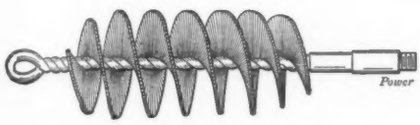


FIG. 11.

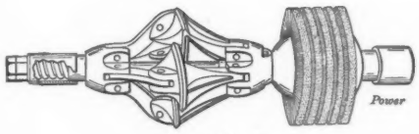


FIG. 12.

scraper shown in Fig. 13 is made by A. W. Chesterton Company. The scrapers cut the soot from the tubes, and it is then pushed out of the tubes by means of the steel brush, the tube being cleaned in one operation. The scraper knives are expanded or contracted by turning the rod to the right or left, thereby moving the adjusting nut up or down on the threaded center rod. The brush is made of tempered-steel wire.

A combination brush and scraper made by the Newark Brush and Scraper Com-

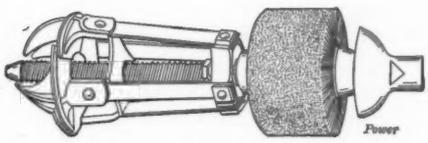


FIG. 13.

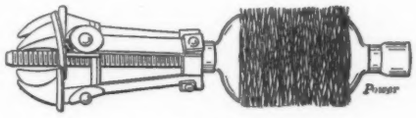


FIG. 14.

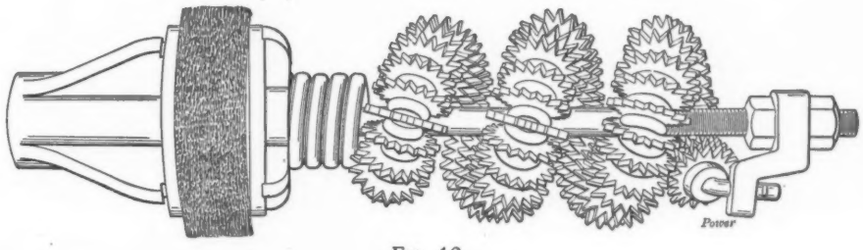


FIG. 16.

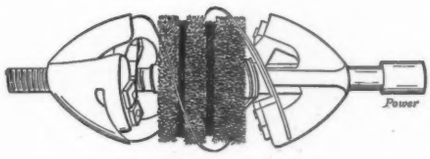


FIG. 15.

pany is shown in Fig. 14. The head is equipped with a malleable-iron scraper which removes the soot from the tube, and the wire brush finishes the work.

The Gem spiral brush tube scraper, made by the Gem Manufacturing Company, is shown in Fig. 15. The scraper is self-adjusting to irregular surfaces in the tube. The spiral-spring blades are made of tempered steel. To facilitate cleaning the tube the brush is placed midway between the two heads. It can be removed and replaced when worn out.

Another design of combination brush and mechanical cleaner has the head driven forward by a spline shaft set in

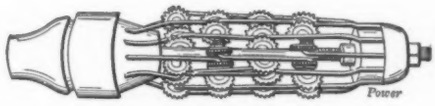


FIG. 17

the hollow shaft of a rotary engine. Fig. 16 shows the type of cleaner used with fire-tube boilers. The spiral portion is composed of small cutters which cut the scale and soot, while the brush at the inner end pushes the loosened deposit out of the tube.

A flexible fire-tube cleaner is illustrated in Fig. 17. It is made up of a series of cutting wheels which revolve between steel-wire springs. This allows the cutting wheels to give in case any obstruction is encountered. At the rear end of the head is a brush which removes the loosened soot. The last two mentioned scrapers are made by the Poole Manufacturing Company.

The Perquisites of an Engineer

Under the above title the *American Journal of Steam and Electrical Engineering* published an editorial which is worthy of repetition and should be given the earnest attention of every engineer.

"An operating engineer is rightfully regarded as one of the chief units in an industrial establishment. It is absurd for an employer to have skilled labor and expert workmen in other parts of his plant and have incompetent men at the power-generating end. Employers generally realize this, but they do not always recognize the fact that the lives of their men and the preservation of their property are dependent in large manner upon the men in the engine room. It is argued, and very often with reason, that employers show their lack of appreciation by failing to pay their engineers commensurate salaries.

"Yet there are causes underlying many of the low salaries, not the least of these is the 'leak' that employers find in the engine room.

"This is not an ordinary leak which takes tangible shape in increased steam consumption, waste of oil and fuels, etc., but a leak from the employer's pocket just the same, which is caused by what is commonly called 'graft.'

"From being a regular calling of its own, 'grafting' has drifted into practically all professions until we find men in all walks of life losing their manhood and self-respect by accepting, and in many cases demanding, little gratuities.

"It is for such men primarily that there has recently been formed the Brotherhood of Stationary Engineers, an organization which does not aim to interfere or injure any of the existing bodies of engineers, but which has for its main tenets and principles the abolishment of all graft, big and little. Any engineer who is discovered accepting a bribe from a salesman is blacklisted by the new organization, who have what they call an honor roll, from which employers can pick men whom they are sure will be absolutely honest.

"To be sure these men will command higher salaries than the grafting class, but employers as a rule are willing to pay something extra for honesty and integrity. When an engineer belonging to this new association is in charge of a plant, his firm can have perfect confidence in his buying material for that plant which is best adapted to conditions, rather than from the salesman who can be bled for the most money.

"The name operating engineer has fallen into reproach on account of the conditions above stated. It will be the task of those men who believe that honesty in little things means honesty in greater things, to revive public confidence."

The Largest Valves in the World

Special Correspondence

Three 9-foot gate valves for the control of hydraulic turbines of 12,000 horsepower capacity each. The body is of cast iron and the gate of cast steel, the latter being raised and lowered by electric power, requiring three minutes for eacl operation.

What it is fairly safe to assume are the three largest gate valves in existence, have recently been constructed by the Chapman Valve Manufacturing Company, of Indian Orchard, Mass., for the Ontario Power Company, of Niagara Falls, Canada. These valves are 9 feet in diameter of water way, and each is to control the water to drive a hydraulic turbine generating 12,000 horsepower. It was found when one of the valves was completed that it weighed 130,000 pounds.

From the various illustrations a good idea of the size of the valve may be had. The overall hight is 30 feet 3 inches and the width is 11 feet. The total thickness over the flanges is 6 feet 8 inches. Due to the size of the gate, a 14-inch bypass valve is provided for relieving the water pressure when opening or closing the valve. Fig. 2 shows the valve body mounted upon a flat car for shipment, and its size relative to the men and the locomotive will be appreciated. The two flat cars are required to handle the parts of one valve. In Fig. 3 is shown the cast-steel gate resting in one-half of the cast-iron body, although the bronze shoe which goes between the gate and the guide is not in place.

In actual operation the valve gate will be under a pressure of 60 pounds per square inch, and the total load carried by the gate will then be more than 550,000 pounds. The gates are of cast steel and weigh close to nine tons each. The valve bodies are of cast iron, heavily ribbed to withstand the pressure, and the valve seats are of bronze, these being held in the body by special bronze, headless screws through the ring face. The usual method of construction for the valve seat, that is, threading it into the body, was not deemed safe because of the heavy pressure around the periphery of the seat. It was feared that this pressure would cause the seat ring to collapse, and so the screws were used to give it a firm grip upon the valve body all around. Tightness between the bronze seat ring and the cast-iron body is assured by lead calking.

Guides are provided for the cast-steel gate, and brass shoes are suitably placed to take the wear between the gate and the guides. At the instant of closing, the valve gate is forced away from the guides and rests entirely against the bronze seat ring, the water pressure holding the gate tightly shut. This final seating upon the bronze ring is attained by putting the seat in on a slight angle, giving the effect of the wedge-shaped plug of an ordinary gate valve.

Raising of the valve gate is accomplished by two tobin-bronze spindles, 4½ inches diameter, with threads of 2 inches pitch. These spindles are 12 feet 3 inches long and are operated through gearing, by

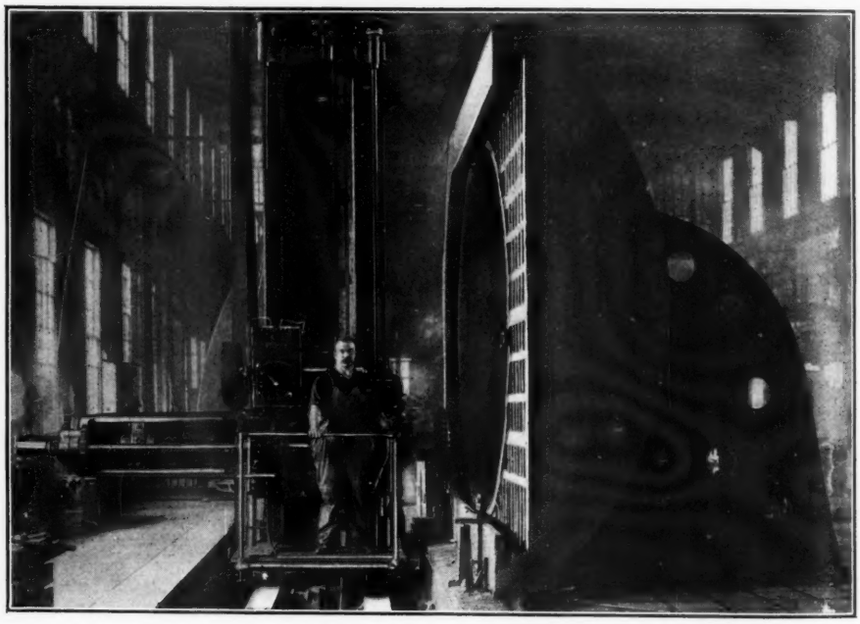


FIG. 1. HALF VALVE BODY ON SELLERS' MILL

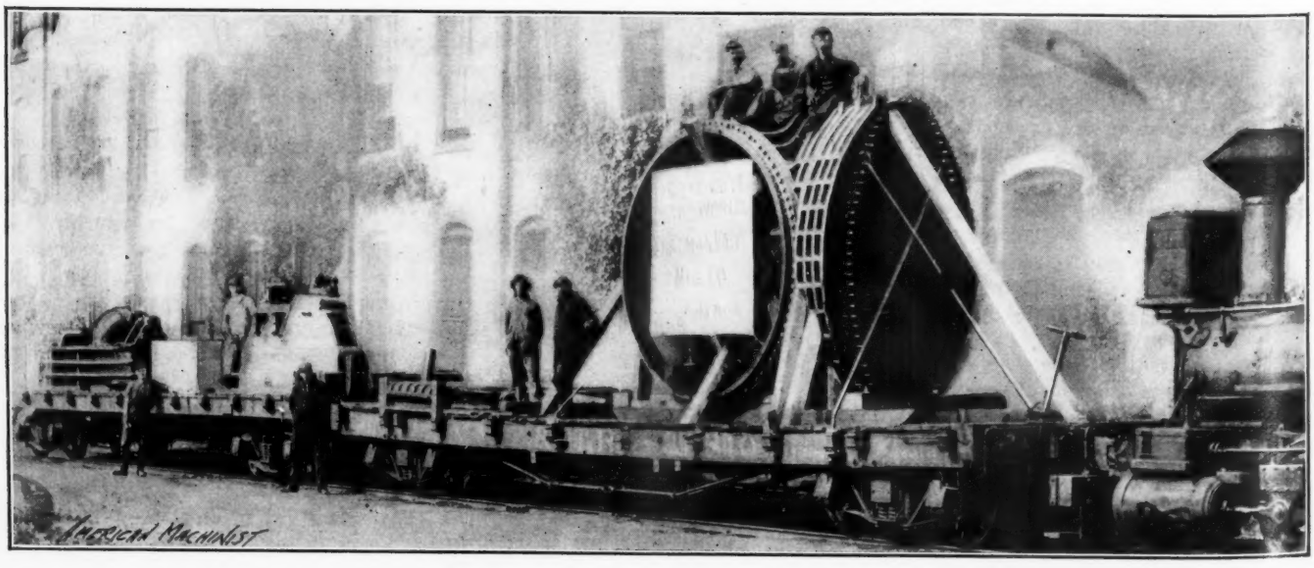


FIG. 2. COMPLETED PARTS OF ONE VALVE, REQUIRING TWO CARS FOR SHIPMENT

a 15-horsepower alternating-current motor, three minutes being required to completely open or shut. To prevent thrashing and knocking of the spindles inside the gate as the former rotate, the spindle sleeves are bored in the cast-steel gate, to an easy fit over the spindles. Automatic limit switches are provided at the top and bottom of the gate travel and arrangements are such that at the end of this travel it is impossible to restart the motor in the wrong direction. If, however, the motor is stopped with the gate part way open or shut, the motor may be restarted in either direction. A magnetic brake assures quick stopping.

As may be supposed the machining of valves of this size is of some interest. In Fig. 1 is shown the milling of the facing of one of the body halves, this work being done in the Sellers' mill. The large angle bracket at the back of the body, and bolted to the bed, keeps the body in an upright position, while the cutter is traveled over the U-shaped surface.

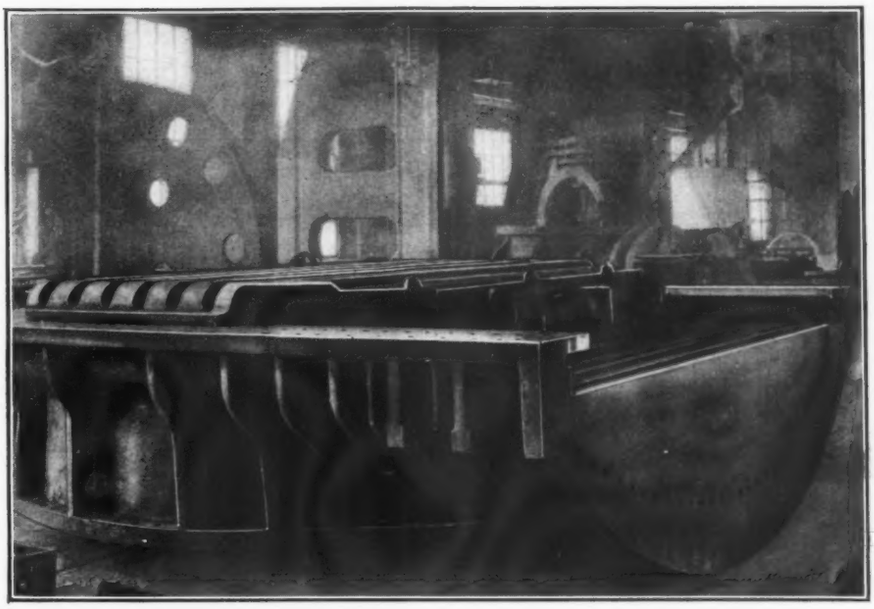


FIG. 3. GATE IN PLACE IN ONE-HALF OF BODY CASTING

Curves for Factors of Evaporation

By Julian C. Smallwood

A self-contained chart giving the factors of evaporization for a wide range of boiler pressures and feed-water temperatures and for qualities from 96 per cent. dry to 300 degrees of superheat. The curves are based upon the heat values given in the recently accepted steam tables of Marks and Davis.

The accompanying chart shows the factors of evaporation for boiler pressures from 15 to 300 pounds per square inch absolute, with steam qualities from 96 per cent. dry to saturated and from saturated to 300 degrees superheat, and feed-water temperatures ranging from 32 to 300 degrees Fahrenheit. The usual formulas for finding factors of evaporation were used in plotting the curves and the heat values were taken from Marks & Davis' new steam tables.

The expression for the factor of evaporation for the three different cases of wet, dry and superheated steam may be written as follows:

For dry steam,

$$F_d = \frac{H - q_1}{970.4} = \frac{r + q_2 - q_1}{970.4}$$

For wet steam,

$$F_w = \frac{q_2 + xr - q_1}{970.4} = \frac{q_2 + r - (1-x)r - q_1}{970.4}$$

$$= F_d - \frac{(1-x)r}{970.4}$$

For superheated steam,

$$F_s = \frac{q_2 + r + C_p(T_2 - T_1) - q_1}{970.4} =$$

$$F_d + \frac{C_p(T_1 - T_2)}{970.4}$$

where,

F_d = Factor of evaporation for dry steam;

F_w = Factor of evaporation for wet steam;

F_s = Factor of evaporation for superheated steam;

H = Total heat in one pound of saturated steam above 32 degrees Fahrenheit, at the given pressure;

q_1 = Heat in feed water reckoned above 32 degrees Fahrenheit;

q_2 = Heat of liquid reckoned above 32 degrees Fahrenheit in one pound of steam at the given pressure;

r = Latent heat of vaporization of one pound of steam at the given pressure;

x = Quality of steam expressed in per cent.;

C_p = Mean specific heat of superheated steam at the given pressure and temperature;

T_1 = Temperature of saturated steam at the given ressure;

T_2 = Temperature of the superheated steam;

970.4 = Latent heat of vaporization of steam at 212 degrees Fahrenheit and atmospheric pressure.

How to Use the Curves

On the "pressure curve" for the given boiler pressure find the point corresponding to the given quality of steam. From this point follow a vertical line downward and note its intersection with the horizontal line marked with the given temperature of feed water. The "factor curve" passing through this point of intersection is that of the required factor of evaporation.

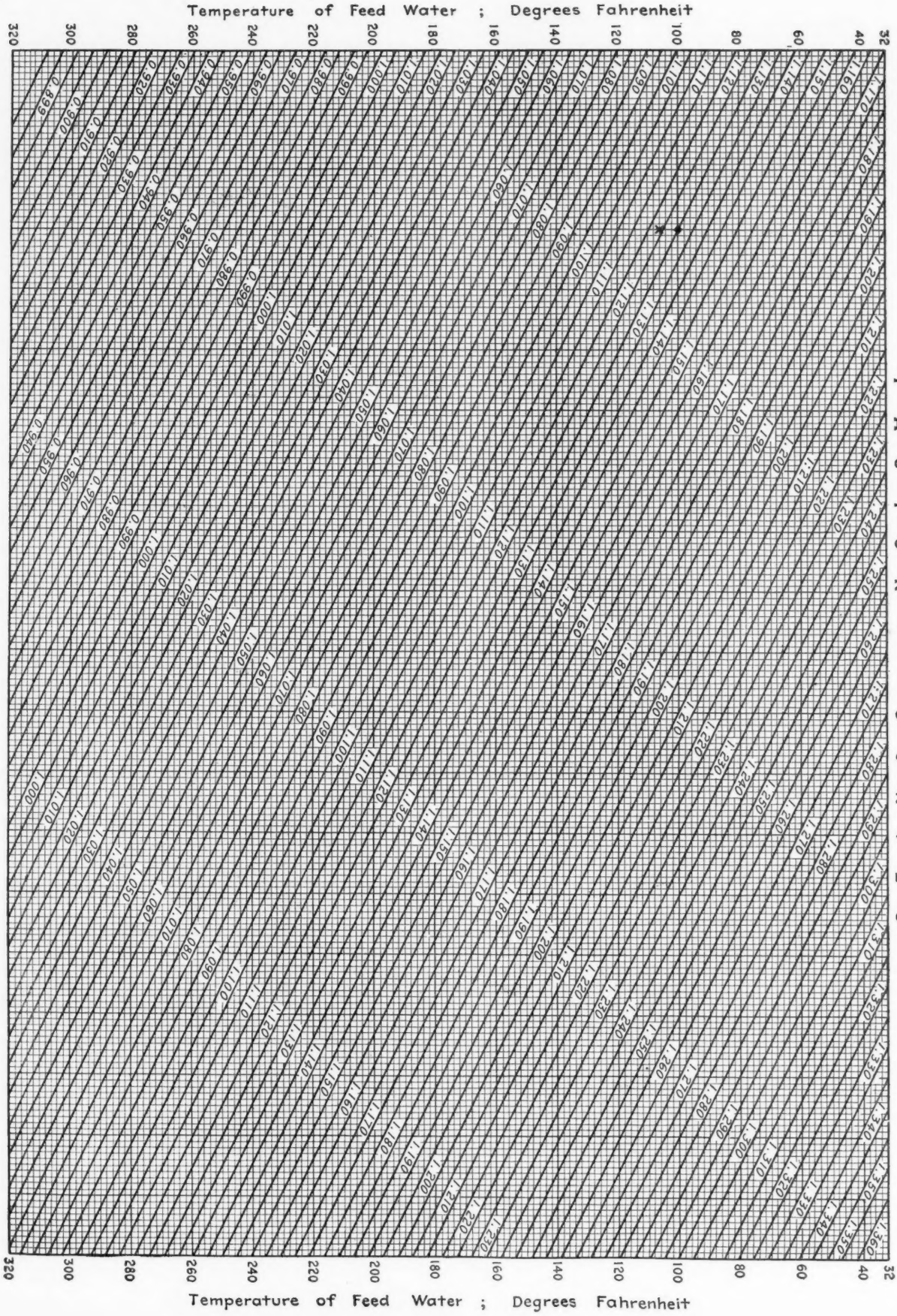
Example

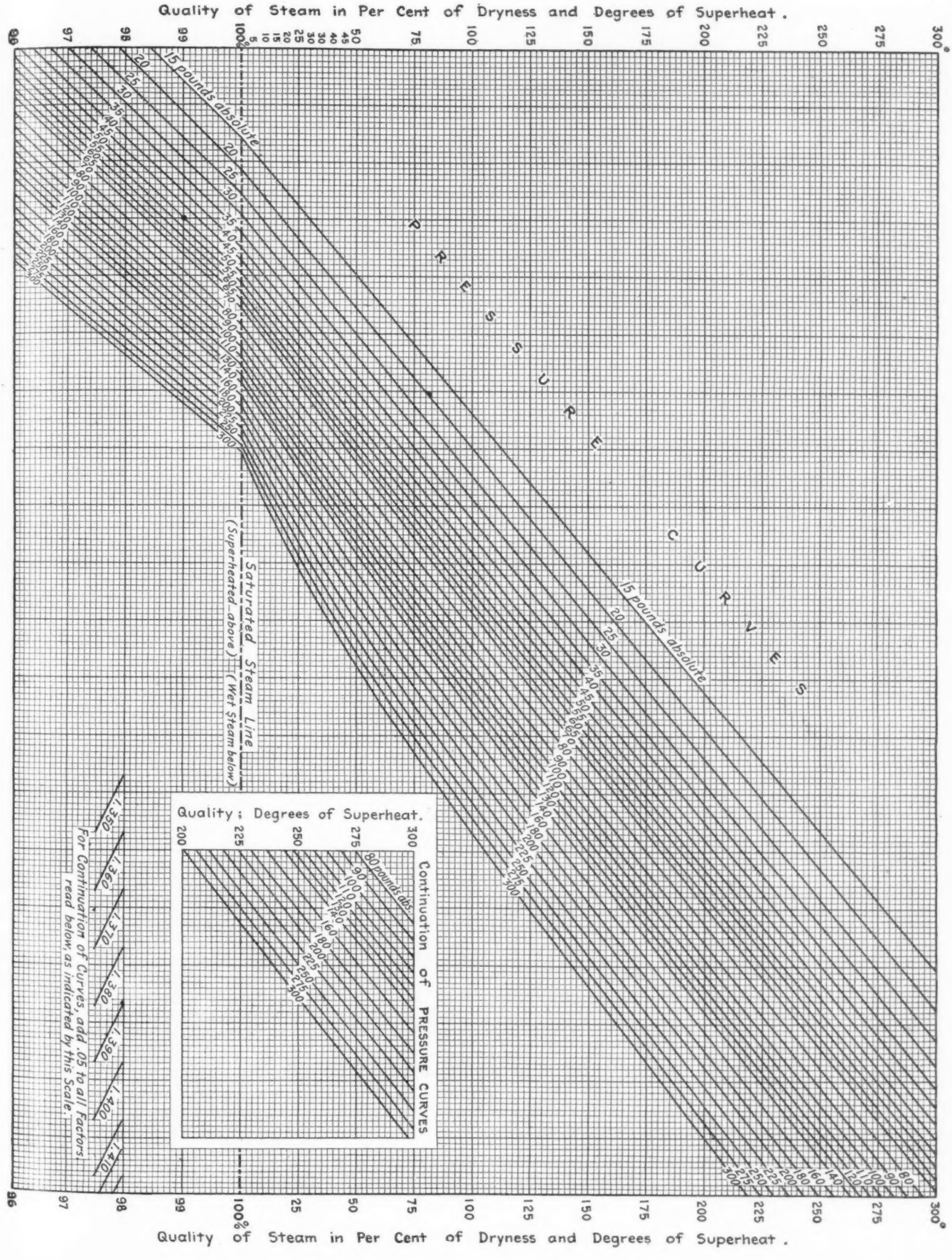
The steps to be taken in solving the following examples are indicated by the dot, square and cross on the chart.

Given a boiler pressure of 50 pounds absolute, a steam quality of 99 per cent., and the temperature of the feed water as 100 degrees Fahrenheit; what is the evaporation factor? Follow the 99 per cent. line to the right until it intersects the 50-pound pressure curve; this point is marked on the chart with a dot. From here follow down the vertical line to the line corresponding to 100 degrees feed-water temperature. Through this point (marked with a square) the factor curve 1.130 passes and this number is the required factor of evaporation.

To Interpolate

Now, suppose that the boiler pressure is 160 pounds, the steam quality 96½ per cent. and the feed-water temperature 106 degrees. Starting at the point in the steam-quality scale corresponding to 96.5, trace horizontally until the diagonal line for 160 pounds is reached. Then trace downward over to the other half of the chart until the vertical line being followed intersects with the horizontal line for 106 degrees feed-water temperature. This point is marked by the cross, and is located between the diagonal factor lines 1.12 and 1.13. Consequently, the first three digits of the required factor are 1.12. The 1.120 curve intersects the 106-degree feed-temperature line 3.7 small divisions to the left of the cross, the 0.7 being estimated; hence the required factor is 1.1237.


Temperature of Feed Water ; Degrees Fahrenheit
320 300 280 260 240 220 200 180 160 140 120 100 80 60 40 32
FACTOR CURVES
Temperature of Feed Water ; Degrees Fahrenheit


Quality of Steam in Per Cent of Dryness and Degrees of Superheat.
PRESSURE CURVES
15 pounds absolute
Saturated Steam Line
(Superheated above) (Wet Steam below)
Quality; Degrees of Superheat.
Continuation of PRESSURE CURVES
80 pounds abs.
For Continuation of Curves, add .05 to all Factors read below, as indicated by this Scale.
1.350
1.360
1.370
1.380
1.390
1.400
1.410
Quality of Steam in Per Cent of Dryness and Degrees of Superheat.

The Effect of Air in Jet Condensers

By Paul A. Bancel

Due to the air contained in the circulating water a larger air pump is necessary with a jet condenser than with a surface condenser. On the other hand, with a jet condenser the temperature of the mixture of air and vapor can be reduced to practically that of the entering circulating water; this is impossible with a surface condenser. The method of figuring the capacities of air pumps is given.

With both jet and surface condensers the size of the air pump and the power consumed in its operation depend largely upon the temperature at which the non-condensable gases are withdrawn. This temperature determines the weight of air in each cubic foot of the mixture of steam and air passing to the pump. If with a 28-inch vacuum the air-pump suction be at 90 degrees Fahrenheit, an air pump to remove one pound of air and steam mixed must have a volumetric capacity of about 710 cubic feet. But if the suction temperature instead of being 90 degrees were 70 degrees, the volumetric capacity of the pump need be only 320 cubic feet. This reduction in volume is explained by referring to Dalton's law of gases, which states that *a constant weight of gas at a constant temperature in a vessel of constant volume, exerts the same pressure regardless of the presence of any other gas or vapor.* In a condenser the total pressure is constant, corresponding in this case to 28 inches vacuum, or a pressure of practically one pound absolute. This total pressure is the result of the partial pressures of the steam and the air. The steam or vapor pressure is determined by the existing temperature; the lower the temperature the lower the pressure. However, since the total pressure is constant, the lower the temperature and pressure of the vapor the higher will be the air pressure, and therefore the air removed will be denser. At 28 inches vacuum and 90 degrees suction temperature, the absolute pressure of the steam in the mixture must be 1.417 inches of mercury; hence the remaining pressure, 0.583 inch of mercury, is the pressure of the air, and this determines its volume per pound.

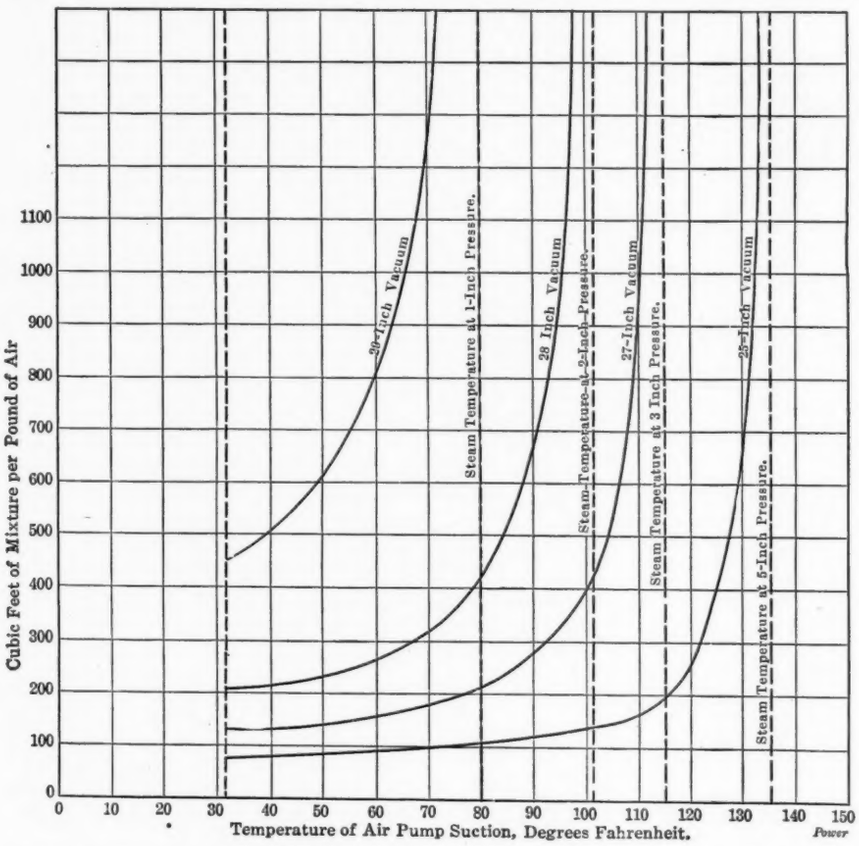


FIG. 1. MIXTURE PER POUND OF AIR AT DIFFERENT TEMPERATURES AND PRESSURES

Knowing the pressure and temperature of the air (the temperature of the air is the same as that of the water vapor), its volume per pound can be determined. At 30 inches of mercury and 32 degrees Fahrenheit the volume of one pound of air is 12.4 cubic feet. According to the law of perfect gases this volume varies inversely as the absolute pressure and directly as the absolute temperature; hence the volume of one pound of air at a pressure of 0.583 inch of mercury and 90 degrees Fahrenheit temperature is

$$\frac{30}{0.583} \times \frac{460 + 90}{460 + 32} \times 12.4 = 710 \text{ cubic feet}$$

Again, when the steam pressure existing in the mixture is that corresponding to 70 degrees Fahrenheit, which is 0.739 inch of mercury, the air pressure must be the difference between that and the total pressure.

$$2 - 0.739 = 1.261 \text{ inches}$$

of mercury. A pound of air at a pressure of 1.261 inches and 70 degrees Fahrenheit has a volume of 320 cubic feet. The curves shown in Fig. 1 are obtained by calculations similar to the foregoing and are useful in determining the air-pump capacity for any conditions of pressure and temperature.

In a surface condenser the weight of air to be removed is considerably less than that to be removed from a jet condenser. In a surface condenser the air which must be removed is that which enters with the steam; namely, that which was in solution in the feed water and that which leaked into the piping and other parts of the system. In a jet condenser in addition to this the air which enters with the circulating water must be handled. Roughly speaking, the air pump of a jet condenser must remove twice the weight of air removed by the air pump of a surface condenser of equal capacity.

It would seem necessary, therefore, to have an air pump of twice the size. This would be true were it not for the fact that with a countercurrent jet condenser a much colder air-pump suction can be obtained than with a surface condenser. The coldest air-pump suction that can be maintained with either type is the temperature of the incoming circulating water, and with a countercurrent jet condenser this is quite possible. However, in a surface condenser, not equipped with an air cooler, there must always be a considerable difference between the temperature of the air-pump suction and that of the incoming circulating water, as the transmission of heat through the tubes depends upon this temperature difference. In practice it is seldom that the air-pump suction of a surface condenser is less than 15 or 20 degrees above the temperature of the incoming circulating water. Fig. 2 shows the effect of the

temperature of the air-pump suction upon the weight of air removed by a pump of 237 cubic feet capacity. With a suction temperature of 50 degrees Fahrenheit and a condenser vacuum of 28 inches, one pound of air would be withdrawn,

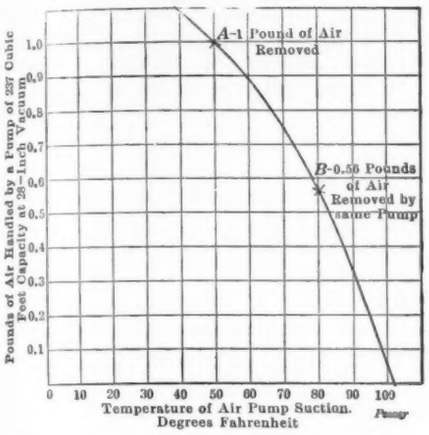


FIG. 2. EFFECT OF SUCTION TEMPERATURE ON AIR REMOVED

as shown by point *A*. With a suction temperature of 80 degrees the pump would handle only 0.56 pound of air, as shown at *B*.

By operating a jet condenser upon the countercurrent principle and cooling the air and vapor mixture, passing to the vacuum pump, to practically the temperature of the incoming condensing water, the great amount of air that must be removed can be handled effectively by a small pump. For reciprocating engines, vacuums of 25 or 26 inches can be readily maintained with small pumps, and vacuums of 28 to 29 inches for steam turbines can be economically maintained with vacuum pumps no larger than are necessary with surface condensers. With such a condenser the air drawn out by the pump is at its greatest density and the amount of steam going to the pump with it is almost negligible. Furthermore, the air passing to the pump, for the greater part is not heated at all; that is, it is drawn from the entering circulating water which contains a large amount of air in solution and which liberates it as soon as it enters the condenser. This air constitutes from 30 to 50 per cent. of the total air removed and, as is evident from the cross-section of a modern jet condenser shown in Fig. 3, the vacuum pump withdraws this air from the top of the condenser where the circulating water has just entered. Thus, with this condenser, the air leaking into the system and that coming in with the steam is cooled to its greatest density, and at the same time the air coming in with the circulating water is withdrawn by the pump before it is heated at all.

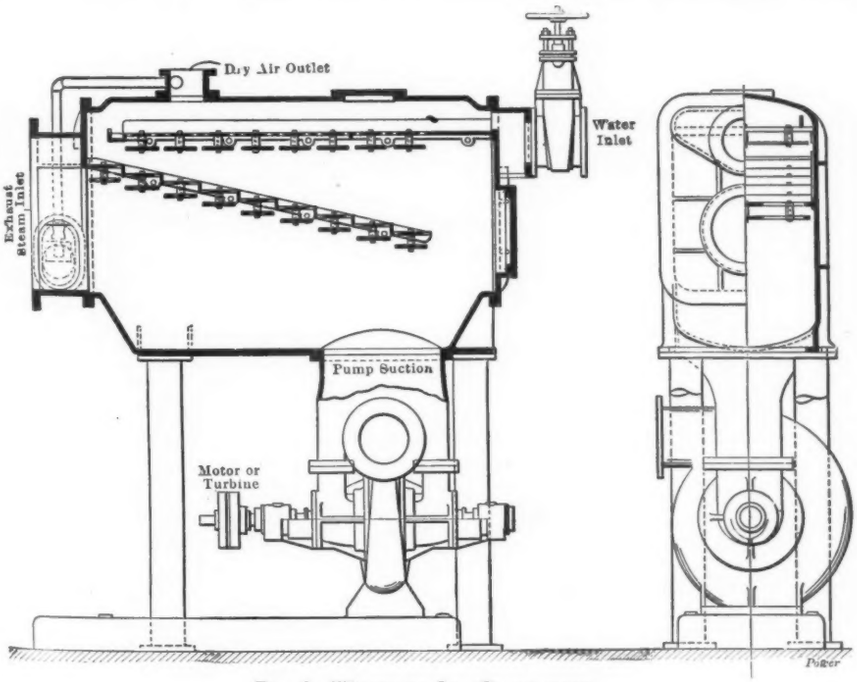


FIG. 3. WHEELER JET CONDENSER

According to Professor Henry, carbon dioxide, oxygen, nitrogen and some other gases are dissolved in the exact ratios of the pressures under which they are exposed to the surface of the liquid, and the solubility of gases in liquids not only diminishes with diminished pressure, but also with increased temperature. From this it is evident that water will hold air in solution in an amount depending upon the temperature and the pressure. As regards the relation of air in solution to temperature, the amount of air which water can hold under a pressure of one atmosphere and at various temperatures, varies according to the curve shown in Fig. 4, which is plotted from figures given in the *Smithsonian physical tables.*

TABLE 1. TEST OF RECTANGULAR JET CONDENSER.

Time.	Corrected Vacuum Referred to 30-inch Barometer.	Steam Temperature Corresponding to Vacuum.	Temperature of Inlet Water.	Temperature of Outlet Water.	Vacuum Corresponding to Temperature of Discharge Water.
6:40	28.52	91	51.0	90.5	28.56
45	28.57	90	51.0	90.0	28.58
50	28.62	89	51.0	91.0	28.54
55	28.67	88	51.0	89.5	28.63
7:00	28.52	91	51.0	85.0	28.79
05	28.57	90	51.0	90.0	28.58
10	28.51	91	51.0	91.0	28.54
15	28.56	90	51.0	91.0	28.54
20	28.57	90	51.0	92.0	28.46
25	28.42	93	51.0	90.0	28.58
30	28.52	91	51.0	89.0	28.63
35	28.42	93	51.0	92.0	28.49
40	28.37	94	51.0	93.5	28.42
45	28.51	91	51.0	92.0	28.49
50	28.21	97	51.0	93.0	28.44
55	28.31	96	51.0	91.0	28.54
8:00	28.55	90	51.0	87.0	28.91

The figures shown in Table 1 are from a test of a Wheeler rectangular jet condenser at the Elmira Water, Light and Railway Company.

A pound of saturated steam at 28.57 inches vacuum has a latent heat of 1041 B.t.u., and with 85 per cent. quality the heat per pound of exhaust steam is 885 B.t.u. Dividing this by 39 degrees, the rise in temperature of the circulating water, gives 22.7 as the pounds of circulating water per pound of steam. In this particular case the turbine exhausting into the condenser was operating under an average load of 2000 kilowatts, and at 15 pounds of steam per kilowatt-hour this would be 500 pounds of steam entering the condenser per minute. Using this figure and the 22.7 pounds of circulating water per pound of steam the weight of circulating water per minute is found to be 11,350 pounds, and dividing this by 62½, the weight of 1 cubic foot of water, gives 181.6 cubic feet of water per minute entering the condenser.

Referring to Fig. 4, it will be seen that for a temperature of 51 degrees each cubic foot of water entering the condenser might contain 0.00157 pound of air. From Professor Henry's law it is evident that the weight of air liberated will be in proportion to the reduction in pressure. With a vacuum of 28.57 inches of mercury, it is found by re-

ferring to the steam tables that if the temperature of the vapor leaving the condenser is 51 degrees the vapor pressure is 0.19 pound, corresponding to 0.38 inch of mercury. Subtracting this from 1.43 leaves 1.05 as the total air pressure in inches of mercury at the exit of the condenser. This is the pressure which determines the amount of air which will be held in solution by the water.

It has been shown by reference to Fig. 4 that at atmospheric pressure and 51 degrees Fahrenheit a cubic foot of water will hold 0.00157 pound of air. Therefore, the air liberated under reduced pressure will be

$$\frac{(30 - 1.05) \times 0.00157}{30} = 0.001515 \text{ pound}$$

of air liberated per cubic foot of water entering the condenser. This represents practically the total amount of air liberated by the cooling water, although to be more accurate it would be necessary to take into account the fact that the water in passing through the condenser is heated about 40 degrees.

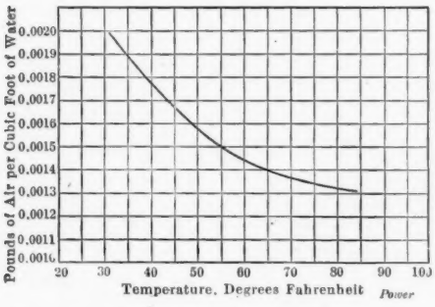


FIG. 4. CURVE SHOWING SOLUBILITY OF WATER AT VARIOUS TEMPERATURES

According to Fig. 4, its capacity for holding air in solution is lessened; hence it liberates free air which must be withdrawn by the vacuum pump. The effect of the temperature upon the air present is small in comparison to the effect of the reduction in pressure. With the pressure reduced to 1.43 inches in the condenser and the air pressure on the water reduced to 1.08 inches of mercury, the amount of air liberated per cubic foot of water is 0.001515 pound and the amount of air still remaining in solution per cubic foot of water is 0.000055 pound. The variation of this quantity with the temperature will be in proportion to the values shown in Fig. 1, so that after the water in the condenser has been heated to 90 degrees there would be further liberated from the water about 0.00001 pound of air. However, at the same time, the air pressure on the water has been reduced to a negligible quantity, since the pressure in the entrance to the condenser, namely, the pressure in the exhaust of the turbine, is due almost entirely to steam. Hence, practically all of the remaining air is liberated from the water. Therefore each cubic foot of water entering the condenser liberates about 0.001515 pound of air before it is heated and 0.000055 pound of air after it is heated.

Knowing the number of cubic feet of water per minute and the amount of air per cubic feet of water, the total air liberated from the circulating water per minute is found to be

$$181.6 \times 0.00157 = 0.285 \text{ pound.}$$

This is the quantity of air which has to be removed per minute by the vacuum pump from the condenser in addition to the air coming in with the steam and leaking in from the various parts of the condenser and piping. Of this amount 0.276 pound is liberated from the cold entering water before it is heated and is therefore in its densest state and can be removed by the vacuum pump with the least expenditure of power and with the minimum size of air cylinder.

The installation at the Elmira Light and Railway Company consists of a rectangular jet condenser and a 10x26x12-inch Wheeler rotative dry-vacuum pump. Figuring the displacement of this air pump, its volumetric capacity per stroke is found to be 3.7 cubic feet, and with a speed of 75 revolutions per minute, the total volume would be 555 cubic feet per minute. Owing to the effect of clearance this capacity is slightly reduced. In this type of pump a rotative valve opens a special snifting port connecting the two ends of the cylinder at the end of the stroke; thus the air mixture in the clearance volume on one side of the cylinder is expanded into the closed cylinder on the other side of the piston. On the succeeding stroke, therefore, very little expansion serves to reduce the pressure of the vapor in the clearance to suction pressure, and this permits the entrance of a greater mixture of air and steam. Assuming that the effect of clearance reduces the air-pump capacity by 5 per cent., the net capacity per minute is then

$$0.95 \times 555 = 527 \text{ cubic feet.}$$

The quantity of air contained in a cubic foot of the mixture going into the pump depends upon the temperature and pressure of the air. Unless the temperature of the air-pump suction is kept quite low the cubic feet of the mixture or the vacuum-pump displacement per pound of air removed becomes excessively large.

In the results shown in Table 1, the vacuum at time 6:45 was 28.57 inches referred to a 30-inch barometer. In the air-pump cylinder the vacuum would be somewhat higher in order to cause the flow of the gases against the resistance of the piping and the pump passages. Assume that the difference in pressure is 0.2 inch of mercury, or, in other words, that the vacuum within the pump cylinder is 28.77 inches. This is the total pressure of the mixture within the pump cylinder. The temperature of the mixture leaving the condenser is close to 51 degrees, the temperature of the incoming water; this temperature would be raised by the absorption of heat in the passage of the noncondensable gases from the condenser to the pump, and within the pump cylinder itself. Assuming that this rise in the temperature is 14 degrees the following will be the conditions:

Temperature of mixture, 65 degrees Fahrenheit.

Corresponding vapor pressure, 29.378 inches vacuum.

Air pressure, 29,378 — 28.77 = 0.608 inches vacuum.

The volume of one pound of air actually within the pump cylinder is, therefore,

$$12.4 \times \left(\frac{460 + 65}{460 + 32}\right) \times \frac{30}{0.608} = 652 \text{ cubic feet}$$

Previous calculations showed that the volumetric capacity of this pump operating at 75 revolutions per minute was 527 cubic feet; hence the weight of air removed by the pump per minute is

$$\frac{527}{652} = 0.808 \text{ pound}$$

Therefore, the circulating water, if saturated with air, may bring into the condenser every minute 0.285 pound of air and the air pump is capable of removing 0.808 pound of air; in other words, the air pump with a jet condenser must be designed to handle a much larger weight of air than would be encountered with a surface condenser, in a proportion of about 3 to 2. On the other hand, with a jet condenser, the temperature of air can be reduced to the temperature of the incoming water while with a surface condenser such low reduction is impossible owing to the fact that a considerable temperature difference is necessary to transmit heat from the outside to the inside of the tubes.

From the figures given it will be seen how essential it is that a jet condenser not only discharge its noncondensable gases at the lowest temperature, the importance of which is shown in Fig. 1, but also that it discharge its circulating water at the very highest temperature compatible with the vacuum, so that the amount of circulating water used, and therefore the amount of air brought into the condenser, is a minimum. If the previously mentioned condenser were so constructed that the water, instead of being heated to 90 degrees Fahrenheit, were heated to only 70 degrees, which is a very fair figure for the old type of jet condenser, twice as much water would have been used per pound of steam. Thus twice as much air would have been brought into the condenser every minute and the vacuum pump would necessarily have been twice the capacity in order to remove the air and maintain the vacuum.

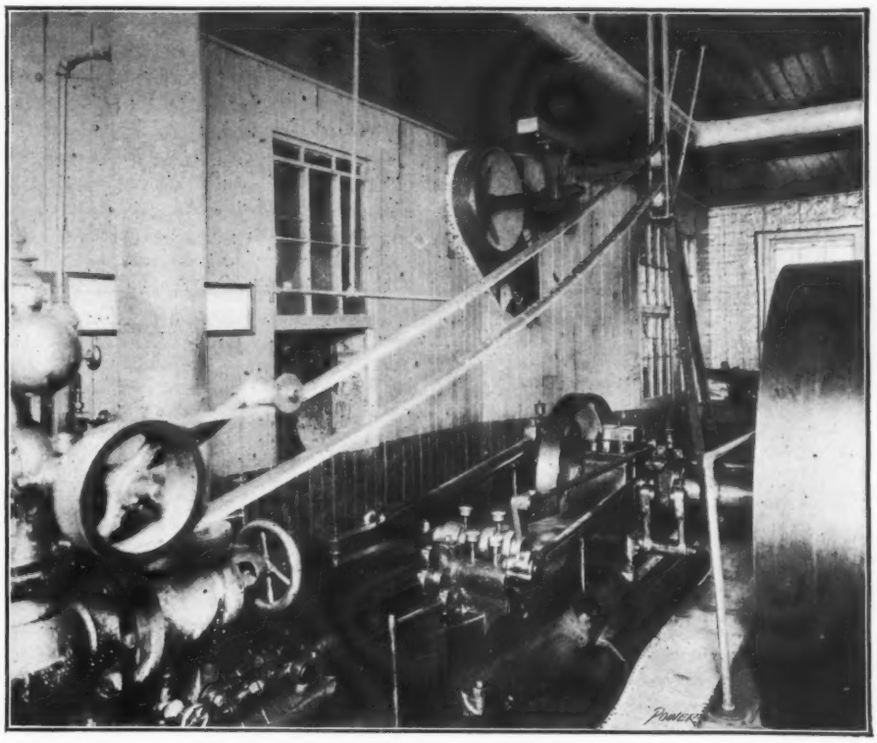
Eccentric Movement on Old Engine

The accompanying illustration shows a peculiar design of steam engine. The cylinder is fitted with one exhaust and two steam valves, the riding-cutoff idea being used. The engine contains a name-plate on which it is stated that it was built by Samuel Secor & Co., 1868. The plate also contains the name, East River Iron Works.

The inner, or exhaust valve, has two valve stems which terminate in a yoke piece outside of the steam chest. The valve is operated by the top eccentric rod, which connects with the top rocker arm. The steam and cutoff valves are both operated by the lower eccentric rod which is connected to the lower rocker arm. The lower rocker arm is fitted with two studs on the inner side of which the valve stems of both steam and cutoff valves are connected. This rocker arm is so designed that the steam valve has the full port travel for each revolution of the eccentric but the cutoff valve has less travel as the stud on the rocker described a smaller arc than the steam-valve stud.

The eccentric strap is of peculiar design. The eccentric is fixed permanently on the engine shaft, but the strap is designed with a link in which the link block of the eccentric rod operating the steam and cutoff valves must have originally been controlled by some type of governor, although no indications remain as to the type formerly used. The exhaust eccentric rod is attached to a stud placed at the top of the link. At the bottom of the link is a boss through which a pin passes and supports the two side pieces forming the eccentric rocker arm. This arm swings on a pin which extends from the engine bed. By this arrangement, the top of the link has considerably more throw than the bottom, hence the motion conveyed to the cutoff valve is quite rapid when opening and closing the steam port.

Nobody seemed to know much about this engine. Even the engineer was not familiar with the design of the exhaust valve. There are two features worthy of notice. The frame, although designed over 40 years ago, has the appearance of a modern tangye frame. The other feature is the design of a crank rod, which is of the solid-end type, fitted with a wedge and adjusting bolt. Whether this rod has been put on the engine since it was first built is not known. If not, it would appear that the builders of the engine were the pioneers of the solid-end rod.



PECULIAR ECCENTRIC AND VALVE-GEAR MOVEMENT

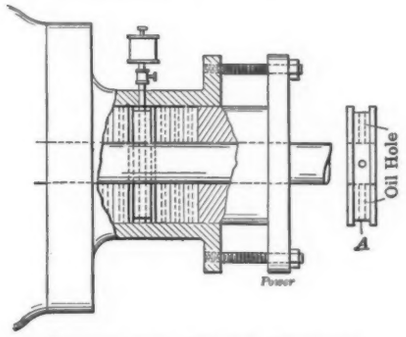
The method of suspending the governor belt is an indication that the engine is not now run as it was designed to years ago. Now, the point of cutoff is fixed, although the cutoff valve has a detachable gear.

Lubricating Piston Packing

Here is a method of lubricating piston packing. A metal ring is made with a ¼-inch channel cut on the outside edge, as shown at *A*. Oil holes are drilled radially through the channel so that oil and graphite may find their way from the oil cup to the piston rod.

The method of applying the ring is as follows: First, two rings of regular packing are inserted in the stuffing box. Then the brass ring, which is made in two sections, is put in place, followed by as much more ring packing as is necessary to fill the stuffing box.

The hole for the oil-cup connection must be drilled so as to come close to the inner edge of the groove in the metal ring when the packing is new. This will allow considerable compression of the packing rings before the groove of the ring has been forced past the oil-inlet hole in the stuffing box. The valve placed below the oil cup makes it possible to feed the oil and graphite at will.



DEVICE FOR OILING PACKING

I leaned my cheer back agin th' wall tother day an' got t' thinkin'. I'd run ingins fer nigh on t' forty years an' I'd never hed a hot box, never hed a brake-down, never cussed th' coal man when he fetched dirty coal, allus hed my salery raised ever time I'd ast fer it, hed run gas'line ingins an' never swore at 'em, an'—but jist at this pint th' dumd water glass busted an' woke me up.

Electrical Department

Primer of Electricity

By Cecil P. Poole

Dynamo Field Excitation

(Continued)

Especially conducted to be of interest and service to the men in charge of the electrical equipment.

As explained in the preceding lesson, the shunt-wound dynamo is used to a much greater extent than the series-wound machine. The reason for this is that the latter type is suitable for only one sort of service, that of supplying a circuit of devices connected in series with each other, as illustrated by the elementary diagram, Fig. 71. In such a circuit, every device must take the same current that passes through every other device in the circuit, so that the only way to make one motors, or whatever forms the "load," must be able to pass 10 amperes. Now, if one device is expected to use 100 watts, then it must use up 10 volts of the electromotive force generated by the dynamo, whereas another device, requiring 500 watts for its operation, must take 50 volts, because the current is restricted to 10 amperes.

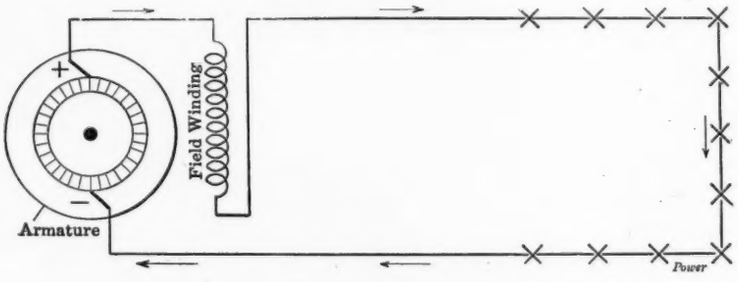


Fig. 71. Elementary Diagram of Series System

It is obvious, then, that the distinction between the parallel or multiple circuit supplied by the shunt-wound dynamo and the series circuit supplied by the series-wound dynamo is that in the former, all of the receiving devices, such as lamps and motors, require the same voltage and take more *power* than another is to have it take a higher voltage.

In other words, if the rate of current flow is 10 amperes in one part of any series circuit, it is 10 amperes everywhere else in that circuit, and all of the lamps, the current taken varies according to the power required, whereas in the series circuit all of the devices take the same current and require different voltages according to the power they utilize from the dynamo.

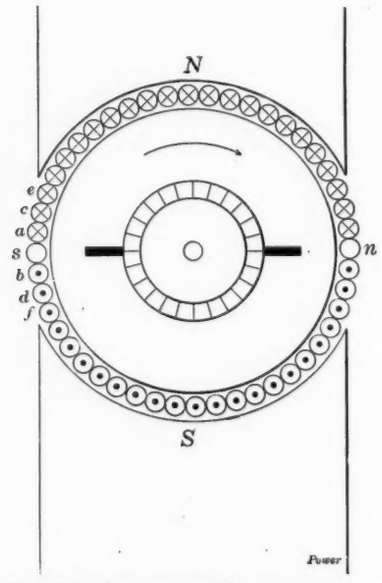


Fig. 75. Armature Currents with Symmetrical Field

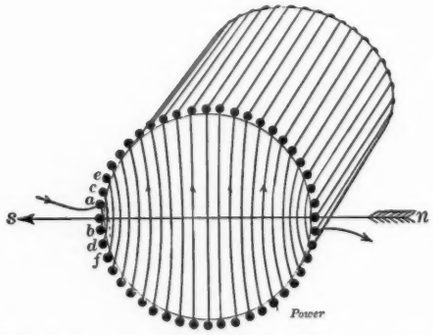


Fig. 76. Electrical Equivalent of the Armature Winding

The Series-wound Dynamo

From the foregoing, it should be evident that the series-wound dynamo must be able to maintain a constant current in the load circuit and to vary its voltage according to the demands of the load. If the rated current of the system is 10 amperes and the load requires 5000 watts (5 kilowatts), then the dynamo must generate 500 volts plus enough extra volts to overcome the resistance of its armature winding and of the line wires which connect it to the load; if the load requires 100 kilowatts, then the dynamo must generate

$$\frac{100 \times 1000}{10} = 10{,}000 \text{ volts}$$

net, because the current must be kept at 10 amperes. This is one of the drawbacks of the series system—this widely varying pressure required. Besides that, a dynamo cannot be made to supply variable voltage and constant current satisfactorily without sacrificing a good deal in the way of efficiency.

Referring to Fig. 71, it will be evident that if some of the load should be cut out by short-circuiting it (which is the only way it can be done in a series circuit), this would reduce the resistance of the circuit, and if nothing were done to reduce the electromotive force of the dynamo the current in the circuit would increase; as the field-magnet winding is in the main circuit, any increase in the current would increase the magnetizing effect of the winding and thereby increase the voltage generated by the armature; this would again increase the current,

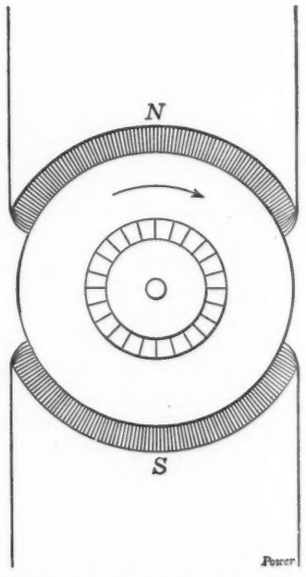


Fig. 77. Symmetrical Magnetic Flux

which would still further increase the magnetization of the field magnet, and so on, until a condition of equilibrium was reached, at which any further increase in the magnetic flux of the dynamo would require a larger increase in current than the increased flux would enable the armature to supply, as described in the case of the shunt-wound dynamo last week.

The series-wound dynamo, then, if built at all on the lines of the shunt-wound machine magnetically, would tend to increase its voltage and, therefore, the line current whenever the load was reduced, instead of reducing the voltage so as to keep the current constant. For this reason, series-wound dynamos are not proportioned magnetically at all like shunt-wound machines. The field magnet is worked at much higher magnetic densities and the armature is wound so as to exert a strong demagnetizing effect on the field magnet. Then, when the current increases, the increase in the armature winding weakens the field considerably

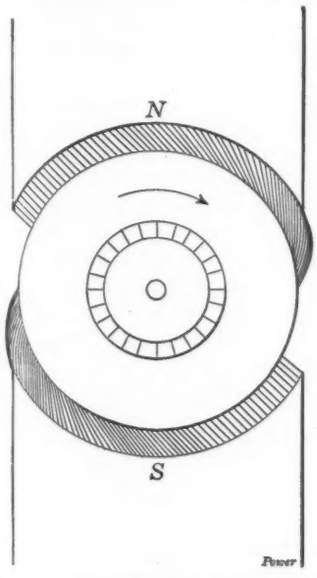


FIG. 78. DISTORTED MAGNETIC FLUX

and prevents the magnet from building up so rapidly. Even with this construction, the dynamo is not anywhere near self-regulating, and an external mechanism has to be used to change the voltage when the load changes.

The reaction of the armature upon the magnetic field in the airgap may be understood by studying Figs. 75 to 79. Fig. 75 represents an armature having 48 conductors, for simplicity; actual armatures of this class have several hundred conductors. If the magnetic flux in the airgaps were not distorted, the brushes would be set as shown and the currents in the two halves of the armature winding would flow as indicated by the crosses and dots in the circles representing conductors; the crosses indicate current flowing away from you and the dots represent currents flowing toward you. The two clear circles at *n* and *s* represent the coils short-circuited by the commutator brushes at the moment. Now, a winding with current flowing through it as indicated here will make a magnet of the armature core, exactly as the winding on the field magnet makes a magnet of that core. The result, magnetically, will be exactly the same as though a coil of wire were wound around the core in the way shown in Fig. 76, and the direction of the magnetic flux that such a winding would produce, if undisturbed, would be as indicated by the large arrow in that diagram. Consequently, the point on the armature core marked *n* in Fig. 75 would be a north pole and the opposite point *s*, a south pole.

Two distinct magnetic fluxes cannot exist in the same space or material, any more than two distinct currents of water can exist in the same stream; they are bound to mix and form a resultant current. Therefore, when the armature winding sets up a magnetic force at right angles to the magnetic force of the field magnet, the two produce a *resultant* magnetic force having a direction somewhere between the two directions of the original forces. That means that the magnetic flux passing between the polefaces and the armature, instead of going straight across and being evenly distributed, as indicated in Fig. 77, will be distorted into something like the distribution indicated in Fig. 78, which will have the same effect on the armature winding as though the field magnet had been twisted out of line. This will shift the neutral point on the commutator, and the brushes will have to be set further around, somewhat as shown in Fig. 79.

Now, supposing that the field distortion caused the brush setting shown in Fig. 79 to be correct for a current of 10 amperes in the armature (5 amperes in each half), the wires *g, h, i, j, k, l, u, v, y, z* are exactly the equivalent of a coil of five turns wound around the armature core so as to cross the ends parallel with the line *x, x*, and carrying a current of 5 amperes. The current in these wires produces a magnetic force directly opposed to that of the field magnet, and any increase in the armature current will exert a direct demagnetizing effect on the field and tend to prevent the increase by reducing the voltage generated in the whole armature winding. Moreover, an increase in armature current would further distort the resultant magnetic field in the airgaps and reduce the inductive effect on the armature conductors as a whole, still further increasing the tendency to keep down the increase in current.

As already stated, however, armature reaction alone cannot make a series-wound dynamo entirely automatic—that is, enable it to keep the line current

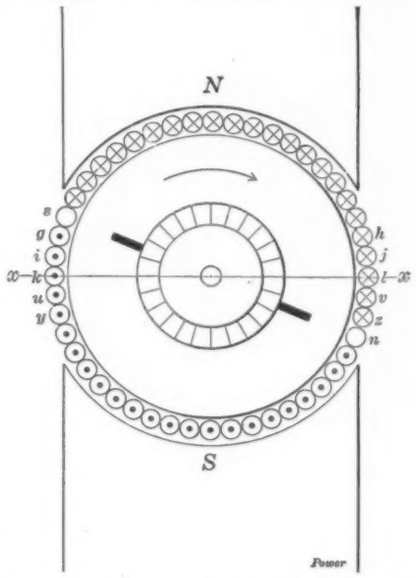


FIG. 79. ARMATURE CURRENTS WITH DISTORTED FIELD

actually constant, although it assists considerably in that direction. In order to keep the current constant, either the field excitation must be reduced when the load decreases or else the brushes must be shifted around the commutator to a point where the e.m.f. generated in one part of the winding is neutralized by an opposite e.m.f. generated in another part of the same half of the winding.

ADJUSTING THE FIELD STRENGTH

The excitation of the field magnet may be adjusted in either of two ways, by cut-

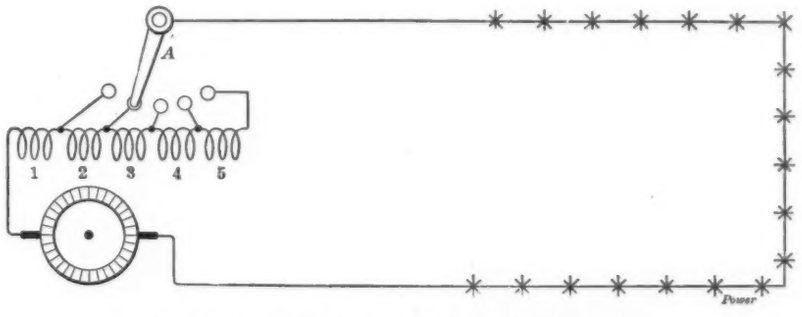


FIG. 80. REGULATION BY VARYING FIELD TURNS

ting parts of the winding in and out of circuit, or by shunting more or less of the current away from the winding. Fig. 80 illustrates the method of cutting in and out of circuit parts of the winding. With the arm *A* resting as shown, the current passes only through sections 1 and 2 of the field winding, the other three sections being out of the circuit; by moving the arm one point to the right (to the

third button) section 3 of the winding would be included in the circuit, and the magnetizing effect would be increased, would be 300 turns active, and a current of 10 amperes would produce 3000 ampere-turns, or 50 per cent. more magnetizing force than before. This method of regulation is never used on machines of appreciable size, because of the flashing that would occur between the arm and the contact button upon moving the arm away from a button in such a direction as to cut out the section connected to that button—from the one on which it rests in Fig. 80 to the one at the left, for example. The cause of this flashing will present it is sufficient to say that it is too destructive to make this method practical.

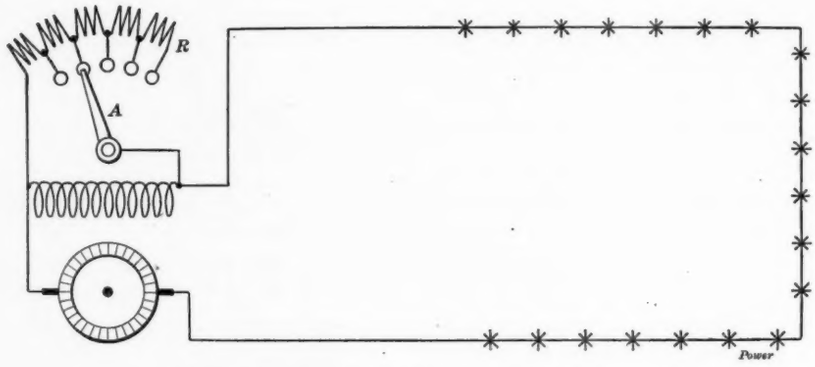


FIG. 81. REGULATION BY SHUNTING FIELD WINDING

Fig. 81 illustrates in elementary fashion the method of regulating the field strength by shunting current away from the winding. A series of coils of high-resistance wire are connected to the regulating switch in exactly the same way that the field winding sections are in Fig. 80. With the arm *A* in the position shown, two sections of the resistor* are connected across the terminals of the field winding and take part of the current away from it. If the arm be moved to the next button on the right, the third section of the resistor will be cut in, thereby increasing the total resistance of the path through the rheostat and therefore reducing the amount of current shunted out of the field winding; obviously, if less current is shunted away, more current will flow through the winding and the strength of the magnetic field produced by the winding will, of course, be increased. For example, if the resistance of each section of the resistor were 100 ohms and the resistance of the field winding were 10 ohms, with a constant current of 10 amperes in the outside circuit and the armature, the current would divide between the field winding and the rheostat as follows:

Resistor Sections in Circuit.	Amperes in Resistor.	Amperes in Winding.	Total Amperes.
1	0.909	9.091	10
2	0.476	9.524	10
3	0.323	9.677	10
4	0.244	9.756	10
5	0.196	9.804	10

In practice the resistor is divided into many more than five sections and the resistances of the sections are usually different, in order to give a more even graduation of the current shunted out of the field winding; and the arm which cuts the sections of the resistor in and out of circuit is ordinarily moved by an automatic mechanism in response to load changes.

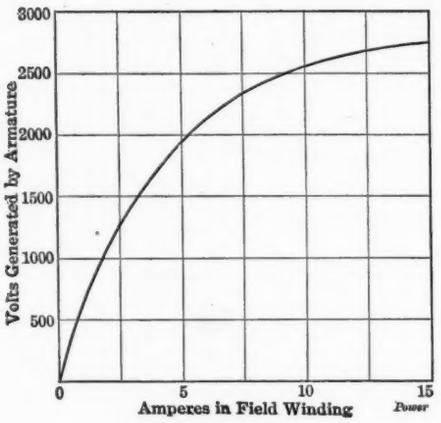


FIG. 82. EXCITATION CURVE

Fig. 82 is the excitation curve of a 2500-volt 10-ampere (more accurately, 9.6-ampere) dynamo running at slightly less than its normal speed. The current in the field winding was supplied from another source and the armature was run without any load. It will be noticed that although 5 amperes in the field winding enabled the armature to generate almost 2000 volts, increasing the field current to 10 amperes increased the armature voltage to only 2550, and 15 amperes in the field winding produced only 2730 volts at the brushes. This indicates that the iron and steel in the field magnet and armature core were "worked" at very high magnetic densities, where the permeability was low and decreased rapidly with higher degrees of magnetization. The curve was plotted from a dynamo of practically obsolete type, but it serves just as well to illustrate the principle of magnetic saturation as a curve from a modern machine would.

*A "resistor" is a conductor used only to add to the resistance of a circuit, or to form a circuit useful only for its resistance. While all conductors have resistance, a conductor is not called a resistor unless its resistance is the only property for which it is used.

LETTERS

Why Does the Motor Make the Lamps Flicker?

At the plant where I am employed there is a 75-horsepower, three-phase, 60-cycle, induction motor which causes the lights to flicker when it is running at full load but not at light load, with the voltage regulator either on or off.

We also have a 60-horsepower 60-cycle motor, and some time ago, when one of the brushes for the starting resistance worked loose, that caused the lights to flicker; after it was tightened the flickering stopped. Thinking the 75-horsepower motor was affected the same way, we took off the brushes, cleaned them up and put more tension on the springs, but the lights still flicker when the motor is fully loaded.

I will appreciate suggestions from other readers of POWER as to why the lights flicker when the motor is running at full load.

LOUIS J. GORILLA.

Ironwood, Mich.

The proper maintenance of hoisting ropes demands, says *The Irish Builder*, constant attention, and efficient lubrication is essential. A lubricant which is recommended by many authorities is formed by mixing a bushel of fresh slaked lime into a barrel of cold tar, or of pure tar and tallow. An equally good mixture is obtained from tar, summer oil, axle grease and a little finely powdered mica, the whole being mixed to a consistency that will work its way into the center of the rope and yet will not dry nor peel. The mixture must, moreover, be of such a character that the rope can be readily inspected, and it should be only thinly applied after the first application. Another mixture recommended by *Mines and Minerals* is formed of graphite or pulverized asbestos mixed with grease.

A man thet works on perpetshul motion is jist like a dog thet chases his tail—he does a lot uv hard hustlin' an' don't get nowhere.

Gas Power Department

Emergency and Alarm System for Ignition Circuits

By William T. Garlitz

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men.

The accompanying diagram shows an arrangement of ignition-circuit connections and auxiliary apparatus that I have found very useful and of a considerable protective nature. A battery is used while starting the engine up, and the ignition circuit is thrown over to a dynamo after the engine reaches its normal speed, but the change from battery to dynamo is made through a solenoid switch instead of directly by the hand switch.

Referring to the diagram: when the three-pole switch is closed upward, it connects the ignition circuit to the positive terminal of the battery through the spark coil, the solenoid switch being on its lower contacts, as shown, and thereby connecting the negative battery terminal to the ignition circuit. The hand switch, when up, opens a little auxiliary switch, the use of which will appear later.

When the triple-pole switch is closed downward, it again connects the positive battery terminal to the spark coil, but it also connects the negative terminal of the switch solenoid to the negative terminal of the generator, through the wires *m m*, and the solenoid lifts its plunger, opening the negative battery connection at the contacts *B* and closing the positive generator connection to the spark coil at the contacts *G*. This is the normal operating condition. Should the generator fail for any reason to give the proper current for ignition, its failure will "kill" the solenoid of the magnetic switch and the plunger will drop again to the position shown in the diagram, closing the contacts at *B*, and thereby putting the battery back on the ignition circuit and preventing a shutdown. The contacts at *A* are also closed, and as the main switch is closed downward, the hinge *h* and jaw *j* are in contact and the alarm bell circuit is closed through a part of the battery, the circuit from the + post of the bell leading through the contacts *A*, the wire *a*, the switch points *j* and *h*, the wire *b*, the battery cells, to the — post of the bell. The ringing of the bell, of course, calls attention to the fact that the generator is not working.

At *W* are two contacts that are bridged by a metal strip when the valve controlling the water-jacket supply is open. The object of these is to sound an alarm if the water is not cut off when the ignition circuit is cut off. The latter operation is done by opening the double-throw switch, and when this is done the solenoid drops its plunger, of course, closing the contacts *A*. With the main switch open, this

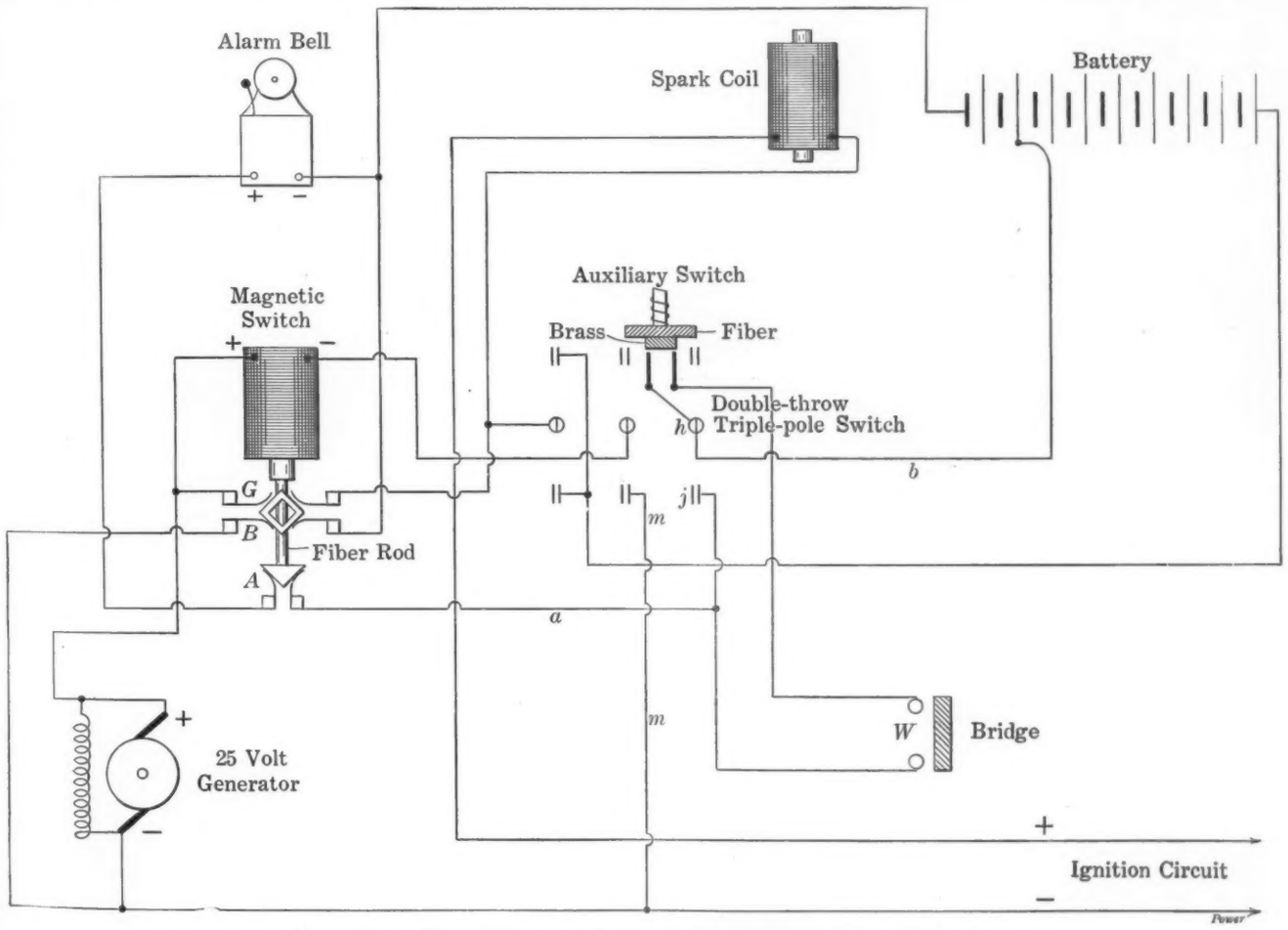


Diagram of Emergency and Alarm System for Ignition Circuits

would not complete the bell circuit without the assistance of the auxiliary switch and the valve contacts *W*. If the water valve is left open, the contacts *W* will be closed, and the wire *a* will be connected to the wire *b* through the contacts *W* and the auxiliary switch, completing the alarm circuit and ringing the bell until the cooling water is shut off, which opens the contacts *W*. This part of the alarm system also serves to call attention to neglect to open the main switch, should that occur when the engines are shut down otherwise than by cutting off the ignition.

A New De La Vergne Engine

Our readers are doubtless familiar with the Hornsby-Akroyd oil engine as built for the past ten years or more. The principal characteristic feature of that engine was a vaporizing chamber connected to the cylinder by a very constricted passage; the oil was injected into this vaporizer at the beginning of the compression stroke, and the heat of the compressed air forced into the chamber by the piston, added to the heat from the walls of the vaporizer, ignited the fuel at the proper moment. Obviously, it is not an easy matter to proportion things so that the oil will be ignited at just the right moment by heat due partly to the hot walls and largely to the compression of the air, especially in large cylinders and with varying loads, which render uncertain the amount of heat that is going to be given up by the vaporizer walls. In small engines this is overcome by very careful design of the constricted passage between the vaporizer and the cylinder.

For large sizes the De La Vergne Machine Company, builder of the Hornsby-Akroyd engine in this country, has departed materially from the old design. The vaporizer opens into the combustion space of the cylinder without any constriction, the oil is not injected until the moment when ignition is desired, and the compression pressure is carried up to such a point as to insure prompt ignition by the heat of compression plus the heat given up by the vaporizer wall. The oil is injected by a compressed-air blast instead of mechanically, and a small air compressor for this purpose is included in the structure of the engine.

The construction of the engine is clearly illustrated by the accompanying engravings, from which the operating processes may also be deduced. Figs. 1 and 2 are quartering views of the rear end of the engine, in which the air compressor *C*, the vaporizer *V*, oil pump *P* and the governor mechanism are clearly illustrated. Figs. 3 and 4 are longitudinal and cross-sections of the engine, the former indicating the relation between the reciprocating parts, the latter the valve gear, and both, the cylinder construction.

The cylinder head, containing the combustion chamber and valve cages, is removable, but as it has an entirely independent water jacket no water packing is required between the barrel and the head and leakage from the water jacket to the interior of the cylinder is impossible so long as the walls remain unbroken. The vaporizer opens into the side of the combustion chamber, instead of the end, as in the old type, and there is no constriction of the opening. Diametrically across the combustion chamber from the vaporizer (see Fig. 4) the fuel nozzle is located. Whether the oil spray is blown actually into the vaporizer or is ignited before it gets across the interven-

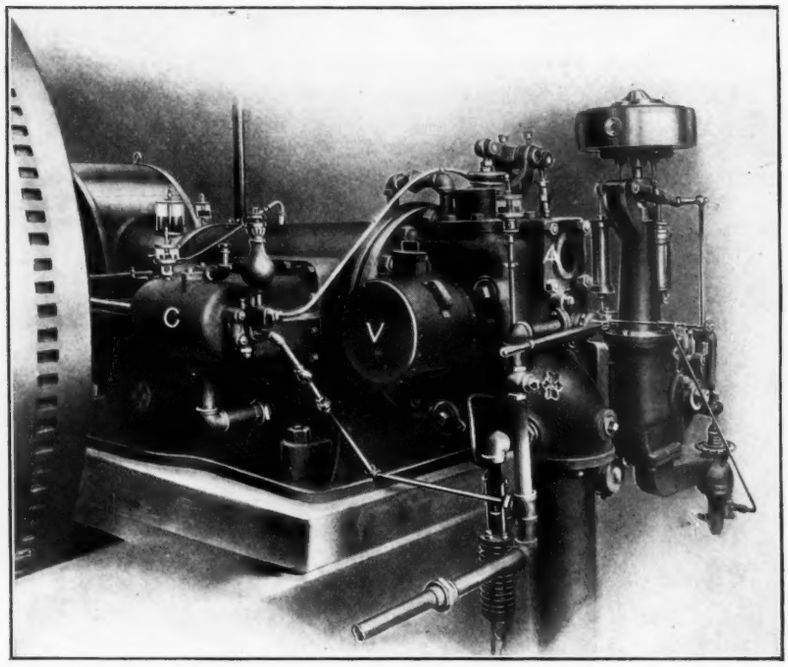


FIG. 1. COMPRESSOR SIDE OF DE LA VERGNE CYLINDER

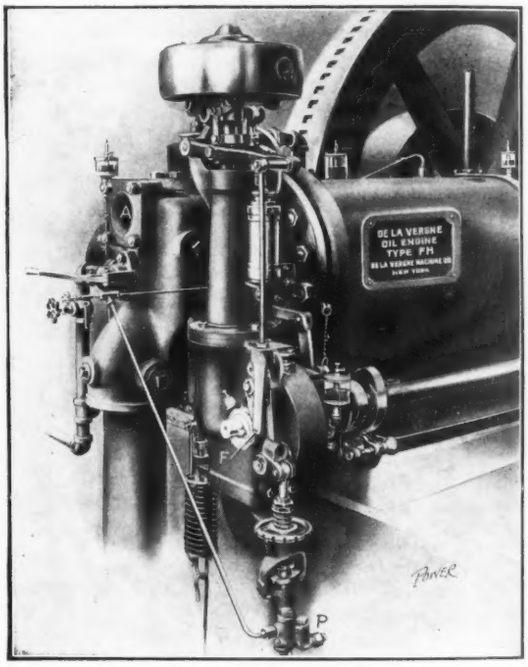


FIG. 2. GOVERNOR AND PUMP

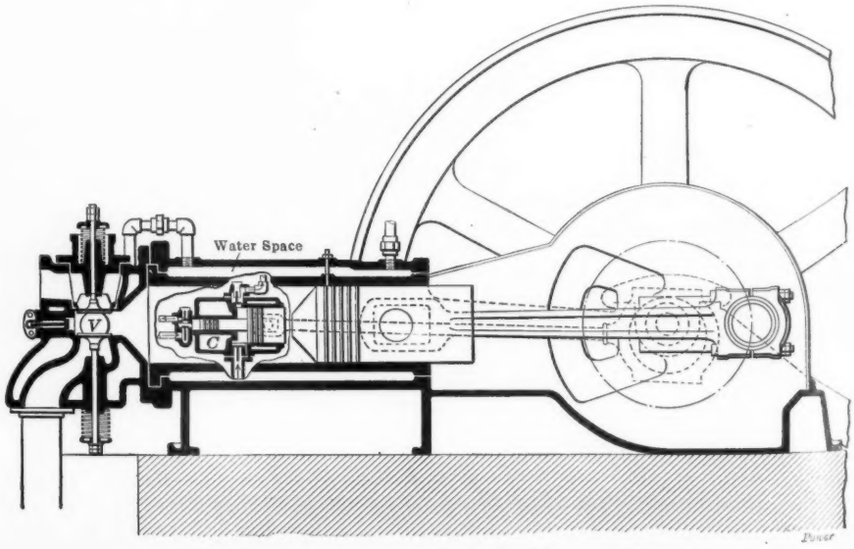


FIG. 3. SECTION THROUGH DE LA VERGNE ENGINE

ing space it is difficult to decide, but the distinction is of no practical importance to the man who owns or runs the engine. The fuel is ignited when blown in by the air blast.

The nozzle is of peculiar construction.

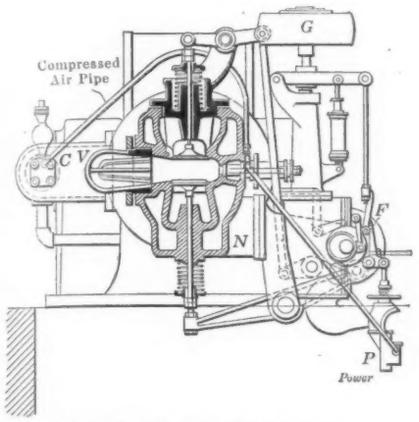


FIG. 4. VALVE MECHANISM

A sleeve, formed as shown at *B*, Fig. 5, fits snugly into the bore of the housing *A* and a pin valve, mounted in the housing cap shown at the bottom of the picture, fits into the bore of the sleeve *B* and is normally held by the spring *C* against a seat in the far end of the housing *A*. When the valve is drawn off its seat by a cam on the lay shaft, compressed air enters at one side of the housing *A* and oil is forced in at the opposite side, and the oil and air pass to the combustion chamber through the network of grooves around the sleeve *B*, which breaks up the oil into fine particles and mixes it very thoroughly with the air. The fuel is ignited in the cylinder, probably by the heat in the air already in the cylinder; part of this heat is due to the compression of the air in the cylinder, which produces a pressure of about 300 pounds per square inch; the remainder is supplied by the vaporizer, which retains heat from the previous combustion. For this

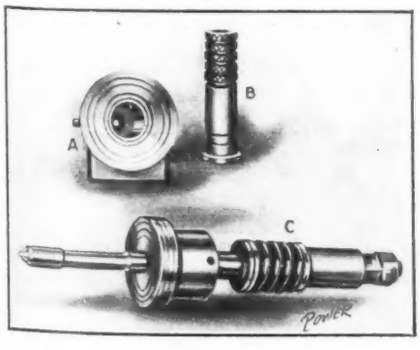


FIG. 5. OIL NOZZLE AND VALVE

purpose it is formed with thin ribs on the interior wall, as shown in Fig. 6.

The foregoing explanation of the ignition process is based on the assumption that the fuel is ignited before reaching the vaporizer. As stated before, it does not matter whether that is true or not. If the oil does not ignite until it reaches the vaporizer, then the explanation is that the ribs of the vaporizer retain heat from the previous combustion and this heat is supplemented by the heat of compression, so that the ribs are above ignition temperature when the compression stroke is completed and the oil blown in. In either case, the air which blows the oil into the cylinder combines with it to form a combustible mixture, which burns in the favorable atmosphere of heated air in the cylinder.

Speed regulation is effected by varying the quantity of mixed oil and air admitted to the cylinder. The governor controls the air supply to the nozzle and simultaneously adjusts the stroke of the oil pump *P* (Figs. 2 and 4), thereby varying the amount of oil delivered to the nozzle. This is done by means of a movable fulcrum roller between the two cam levers which actuate the pump plunger. This roller is shown in Fig. 4 at *F*. The lever to the left of it is moved by a cam on the half-speed shaft and its motion is transmitted by the roller to the lever

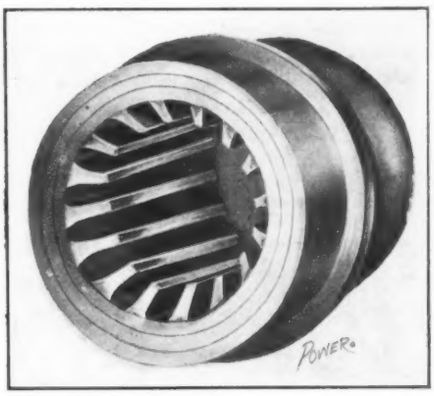


FIG. 6. DE LA VERGNE VAPORIZER

at the right, which forms one arm of a bell crank; the other arm is connected to the pump plunger. When the governor draws the roller upward, the stroke of the pump plunger is decreased, and *vice versa*.

In Fig. 3 the cylinder wall is shown broken away, in order to reveal the sectional view of the air compressor. This is a two-stage machine, with two single-acting plungers arranged as shown at *C*. It is driven by an eccentric on the main crank shaft, set about 90 degrees ahead of the crank. The air compressed by the first-stage plunger is delivered to a tank at about 150 pounds pressure and this tank is automatically kept filled to that pressure; from it is taken the air for starting the engine. The high-pressure plunger of the compressor also draws from the tank and the quantity of air taken is controlled by a valve actuated by the governor in such a way as to maintain almost constant the quality of the mixture delivered by the nozzle; it is somewhat richer at full load than at no load.

The piston of the engine draws in the same quantity of air at every suction stroke, and the compression pressure is therefore almost constant. At full load

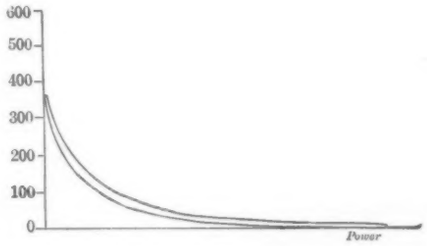


FIG. 7. NO-LOAD DIAGRAM

this air is necessary to the complete combustion of the fuel mixture, but at light loads there is an excess. The indicator diagrams, Figs. 7 and 8, illustrate the approach to uniformity of compression pressures. The apparently higher pressure at no load is probably due to the more nearly instantaneous combustion of the charge. Fig. 8 shows a pressure rise of only 100 pounds, from compression to maximum, with a short horizontal combustion line, giving the full-load diagram area with much lower maximum pressure than the usual sharp-peak diagram would show for an equal area.

The engine is built in single-cylinder form from 85 to 175 horsepower and of correspondingly doubled rating in twin-cylinder form. The guaranteed maximum consumption of crude oil, distillate or

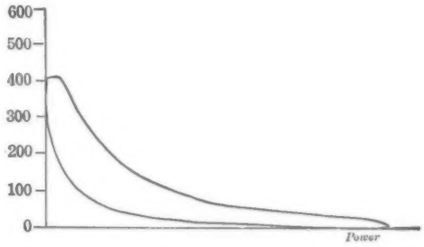


FIG. 8. FULL-LOAD DIAGRAM

cheap fuel oil is six-tenths of a pound per brake horsepower-hour at full load and three-quarters of a pound at one-fourth to one-half of full-load rating.

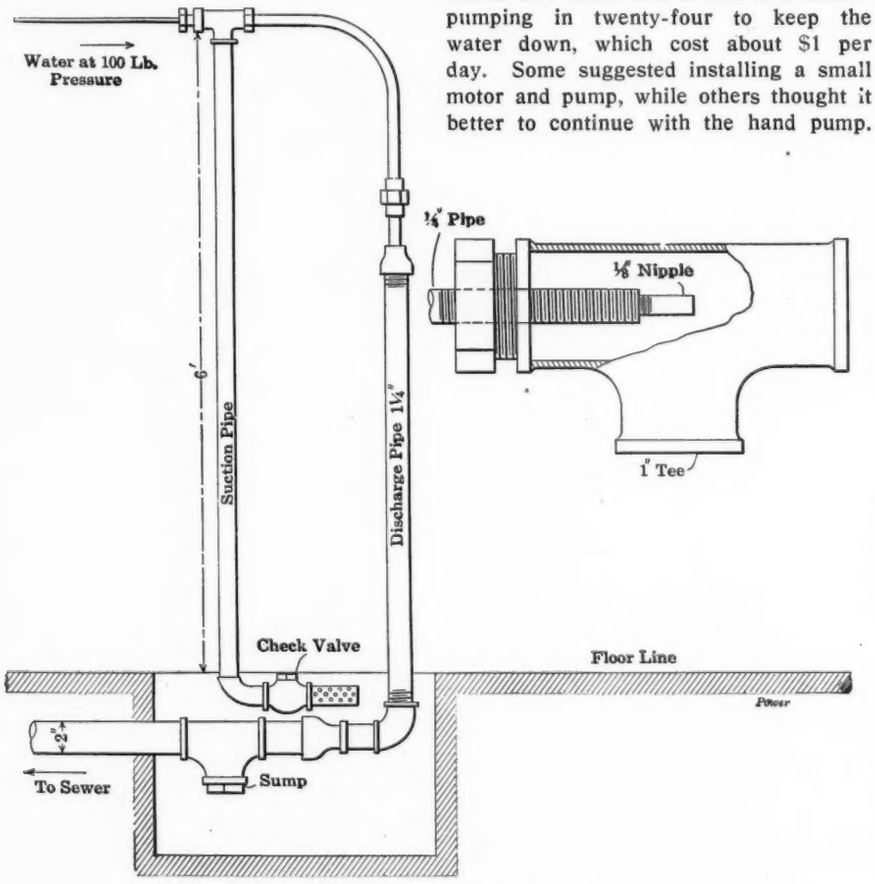
A paper read to the American Society for Testing Materials by Charles Macnichol, describes a method of obviating the trouble caused by the action of cement upon the oil in paints employed for covering concrete surfaces. The author recommends the application of zinc sulphate dissolved in an equal weight of water, the solution to be laid on by an ordinary brush after the concrete has become dry. Doctor Cushman expresses the opinion that the effect of the zinc solution is to fill the pores of the concrete with mixture of gypsum and zinc oxide, neither being injurious to oil paint.

Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words, wanted.

Removing Seepage by Siphon

A building had been in process of construction for about eighteen months, and when finished it was found that the trunk sewer in the street had not been completed, and would not be opened for several months. A number of drains and some surface water emptied into the sewer and this water began to back up into the building, the installation of a back-water valve having been overlooked when the drainage piping was laid out. In the early fall the water would at times be an inch or two in depth. Not being familiar with the ground, the sewer and the layout of piping, I was at first somewhat puzzled at the rise and fall of the water, as I visited the building only once or twice a week and had not had an opportunity for close observation.



RELATIVE LOCATION OF SIPHON

It was also found that the seepage water into the basement amounted to about one barrel per hour.

When the fall rains began and the building was occupied, there was immediate complaint, as the water backing into the basement interfered with the operation of the boiler, and the building had to be kept warm at any cost. In an attempt to keep the water out the regular inlet was plugged with a plumbers' test plug and a temporary riser of 1¼-inch pipe was connected where the cleanout plug had been. A common well pump was then installed and operated by hand, and it was found that it took four hours' pumping in twenty-four to keep the water down, which cost about $1 per day. Some suggested installing a small motor and pump, while others thought it better to continue with the hand pump.

Then I decided to get the water out upon my own responsibility. I procured a 1-inch tee, a 1x¼-inch bushing, cut a long thread on a ¼-inch pipe, screwed it into the bushing, and the bushing into one end of the tee. The ¼-inch pipe, however, was tapped on the inside for a ⅛-inch pipe, and a ⅛-inch nipple was screwed through so as to slightly pass the branch of the 1-inch tee. A bend of 1-inch pipe was then fitted into the other end of the tee, and with the union it was coupled onto the 1¼-inch temporary riser. It was found that the arrangement did not work successfully until the smooth bend was put on, after which it worked nicely.

The tee was placed about 6 feet above the floor, as it was thought at that time that the water might back to that hight in the basement before the sewer could be opened. The suction pipe was then put in the branch of the tee with a check valve and strainer. The ¼-inch pipe was then connected to one of the service pipes in the building, and when the valve was opened it was found that the water could be lifted 6 feet without any trouble. The water pressure was 100 pounds per square inch.

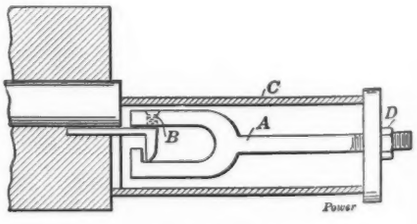
I believe that it would be possible to keep the basement dry no matter how high the water rises in the sewer, or as long as the seepage does not exceed four or five barrels per hour, which I do not anticipate. However, if more than that amount should come in, the capacity of the siphon could be increased.

H. R. ROGERS.

Seattle, Wash.

Key Jack for Corliss Valve Stems

The accompanying sketch shows a convenient method of removing the key from the valve stem of a Corliss engine. The hook *A* is made of soft steel and contains the set screw *B* the head of which is flush with the jaw of the hook. The collar *C* is a piece of pipe, bearing against the end of the stem and steam arm, and cut to fit these so that it will stand out when the key is being drawn. By turning the nut *D* the key may be gradually drawn out.



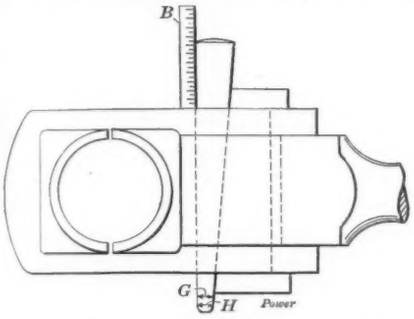
KEY JACK

C. W. GREENLEAF.

Lynn, Mass.

Driving Keys

When driving keys it is almost universally the custom to make a scratch with a knife or some other sharp instrument, thus permanently disfiguring the key, which, after a while, becomes scratched all over, making it almost impossible to tell which was the latest mark. When driving a key for the first time, if there is no sideplay or if the connections are so large that they cannot be moved sideways in order to determine the degree of tightness, the key should be driven solid and then backed out about a quarter of an inch depending, of course, upon the taper. The taper of the key should always be noted as the greater the taper the less the key will have to be driven.



SCALE IN POSITION FOR MEASURING DISTANCE KEY IS DRIVEN

While visiting an engine room recently, I became interested in the manner in which the engineer adjusted the lost motion in the crosshead and crank-pin boxes of his engine. In this instance the engineer instead of scratching the key, merely laid a rule on the strap, and taking his pencil drew a line across the key, using the rule as a guide. After the boxes have once been brought up snug it can be determined very accurately how much the key must be driven each time. This I have found with the average key to be about 1/16 inch, although in some cases 1/32 inch is all the boxes will wear; yet the inexperienced engineer often hits the pin with a blow from a hammer, as it comes around.

Another method is to take a scale or rule and set it up in front of the key as at *B* in the accompanying sketch. After driving the key, again note the reading on the scale and the distance it has been driven can be easily ascertained. When a key has been driven so far that liners are required, the thickness of the liners can be found by measuring across the key close to the bottom of the gib as at *G*, and then again at the bottom of the key at *H;* the difference between these measurements will be the thickness of the liner necessary to bring the bottom of the key up to the bottom of the gib. When taking apart to put in liners there is no way of marking the key to know just how far to drive it. When replacing again, it should be driven solid and then eased back.

It should be remembered, however, especially on engines of small clearance that the wear is continually making the rod shorter and bringing the piston nearer the crank end of the cylinder. Putting in liners carries it back, and as both parts of the box have been worn, part of the liners should be put on the strap side or there may be danger of knocking out the back head of the cylinder. Some builders arrange a key one side of which draws upon one side of the pin and the other side on the reverse side of the pin, in which case one shortens the rod and the other lengthens it, thus tending to equalize the wear and keep the rod approximately the same length. It is the practice among many modern builders to make solid ends and put in a wedge to be drawn up with a screw. In such cases it is necessary only to get the number of threads to the inch and ascertain the distance that one turn of the nut will draw the wedge, after which it becomes as simple as a key that is in plain sight.

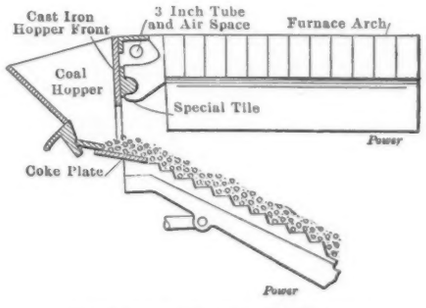
CHARLES H. TAYLOR.

Bridgeport, Conn.

Furnace Alterations

At the plant where I am employed, we have had considerable trouble from the furnace fronts of the boilers burning out. The boilers are arranged in pairs, separated by a dividing wall, and the two outer sides are finished with glazed brick. Each boiler is fitted with a mechanical stoker of the front-feed inclined-grate type.

The first cause for concern came when the glazed-brick setting at the side of the furnace front bulged and cracked. This was caused by the expansion of an angle iron, which extended the full width of the two boilers and acted as a support for the cast-iron fronts of the coal hoppers. Our bricklayer then increased the thickness of the wall at this point. This prevented the wall from cracking, but gave us another source of worry in that instead of the angle expanding lengthwise it bowed down. The cast-iron front of the hopper has a lug riveted to it which acted as a support for the special tile shown in the sectional view.



SECTION THROUGH FURNACE

The groove in the tile engaged the lug, and the other end rested against the furnace arch. When the angle bowed, the tile fell below the arch, exposing the cast-iron front to the heat and resulting in a burnt plate. This allowed the coal to fall into the furnace and be wasted, besides involving a considerable expense for repairs. The remedy was effected by inserting a piece of 3-inch boiler tube in the wall, as shown in the sketch, and having the tile placed with a small space between. This allows the draft to draw air through the tube, over the tile and into the furnace through the cracks. This circulation of air keeps the angle and tiles cool and the cost of repairs is reduced to a minimum.

Although some of the experts on CO_2 will no doubt say that we are wasting fuel, the waste resulting from the unburnt coal that found its way into the furnace through the burned-out front and the expense of repairs far outweighed the reduced economy from the slight reduction in CO_2 caused by the extra air.

One of the boilers was repaired in this way eight months ago and the results have been so satisfactory that we are effecting the same change in the remaining boilers.

H. R. BLESSING.

Philadelphia, Penn.

Removing Clinkers from Furnace Walls

Probably most engineers and firemen have experienced trouble with clinkers adhering to the side and bridgewalls of furnaces, and, although the remedy for this may be known to many, there are, no doubt, many who have not heard of it. To better illustrate it I will cite the first case of my own.

A number of years ago I took charge of the steam plant in a small hotel containing two horizontal tubular boilers, 16 feet long and 54 inches in diameter. It was in the afternoon that I took charge and before I had had time to look around the plant the fireman on watch told me that his relief had arrived and that he was going home. I at once went into the fire room and met the other fireman, who was a young man but had held his present job for some time. In view of this, I thought it best to let him do as he had been accustomed until I had become better acquainted with both the men and the place; therefore, I went into the engine room and sat down.

Before long, I heard the rattle and rasping of the fire tools and supposed that the fireman was about to clean the fires, but was soon surprised to hear a dull thud at intervals of a few seconds. I roamed around the engine room, listening, and finally went out into the fire room. The young fellow was cleaning the fire in one of the boilers and as I came around the corner he made a jab at the side wall with a slice bar and before I had a chance to say anything he withdrew the bar to arm's length and

slammed it into the wall again. I at once stopped him and then looked into the firebox. The fire was pushed to one side and the side wall and bridgewall had a solid clinker about 6 inches above the grate, extending out over the grate about 8 inches, thus reducing the size of grate surface considerably. I asked him what he was doing and he replied, "I am trying to get these clinkers off the wall." I told him that he would knock down the wall by going at it in that way, and directed him to leave the clinkers there for the time being.

Upon returning from supper that evening I happened to stumble over a half barrel of oyster shells and wondered why they had been left in the passageway. As I was sitting in the engine room a few minutes later, it occurred to me that I had read in an old Farmers' almanac that a handful of oyster shells if thrown in the kitchen stove would effectually clean the brick lining. I reasoned that if such were the case they ought to clean the lining of a boiler as well. I had the fireman get the oyster shells and told him to throw a few shovelsful along the side walls and across the bridgewall about an hour before he cleaned the fire. He did as directed and in three days the walls were free from clinker. I have tried this many times since with both oyster and clam shells and have never seen it fail, even in the most stubborn cases of clinker.

W. N. WING.

Brooklyn, N. Y.

Faulty Design

I used to envy the man who sat in an office, drew plans on paper, smoked black cigars and carried a slide rule in his pocket, but I have since changed my views, partly as a result of the experience which is related in the following.

Not long ago I took charge of a new plant which had just been finished and tested, and was ready for operation. The machinery had been installed by one firm of mechanical engineers, the heating system by another and a consulting engineer had been employed to design the plant and to superintend the installation. All equipment and material used were first class.

The first mistake made was that of installing the equipment before the building was near completion. This subjected the machinery to moisture and dirt, and consequently it was in very bad condition when the plant began operation. We learned that the plant had been tested the winter before and upon firing up, found that the piping had not been drained as it should have been after testing and consequently a number of fittings and valves burst. The water ends of both feed pumps were frozen and burst and new water ends had to be ordered. When all broken fittings and valves had been replaced, a cold snap came and steam was called for.

The overhead system of heating was used, an 8-inch pipe carrying the steam to the top of the building, a distance of about 100 feet, from which point it was distributed. Upon turning on the steam, it was found that this pipe was filled with water and that no bleeder had been provided to drain it. Consequently the pipe had to be tapped and a bleeder put in. Steam was again turned on and upon trying to start the return pump it was found that this had not been packed. The return pump and tank were located in a pit with only about 6 inches clearance between the walls of the pit and the pump, so that it was necessary either to take the pump out or to dig the pit larger in order to get at the pump to pack it. As there was plenty of waste space around the pump pit, we at once set to work and enlarged the pit.

The engines and generators were much too large for the work they were required to perform, one of the two machines being able to carry the peak load alone, although it ran for about two-thirds of the time at 30 per cent. of its rated capacity.

The exhaust pipe from the engines was carried about 3 feet below the floor, which placed it below the sewer, so that the water and oil from the exhaust steam could not be drained into the latter. In trying to remedy this condition a drain had been attached directly to the bottom of the separator and run up 2 feet into the blowoff line of the boilers. We, of course, had to disconnect this drain, put in a trap, dig a pit to catch the discharge from the trap and install a small jet to lift it to the sewer.

The steam header above the boilers was drained by a trap the discharge of which was connected directly to the sewer. This was changed and made to return directly to the boiler. The drain from the hotwell was connected directly to the house sewer; hence, when a boiler was blown down, the steam and hot water passed through the plumbing all over the building. This also had to be changed and an independent sewer put in.

The main steam line from the steam header to the engine was run straight from the header to the engines with no provision made for expansion, and the blowoff pipes from the boilers passed through a concrete floor which was cast around the pipes so that there was no room for them to move as the boiler expanded or contracted.

The water-column pipes were run directly through the furnace wall and into the side of the boiler, with no protection whatever from the fire.

The heater used for heating the water supply for the building was too small and another thousand-gallon tank had to be installed for that purpose.

A bypass had been put in around the pressure-reducing valve, as is usually done, so that the steam may be run through the bypass while the reducing valve is being repaired; but no valve had been put on the high-pressure side of the reducing valve, hence the steam could not be shut off from the high-pressure side of the reducing valve while repairing it.

The feed-water pumps were both connected to the same exhaust pipe, with no valve between the two connections. This necessitated both pumps being shut down in case the steam end of either had to be repaired.

The consulting engineer had failed to mention in the specifications the kind of service required of the generators; hence, there was a drop of about five volts every time the elevator load was put on, thus causing a bad flicker of the lights. Also, when the elevators arrived it was found that 220-volt motors had been specified, while the voltage carried in the plant was only 110. This necessitated a change in motors, costing about $475.

An ice-water circulating system was installed and the ice water was circulated by means of a steam pump, the water and steam cylinders of which were so close together that the steam cylinder heated the ice water as it passed through the pump. This pump had to be taken out and a motor-driven rotary pump installed, which effected a saving of about $1 per day in the ice bill.

Several other changes had to be made at a total cost of about $1000 before the plant could be put into successful and economical operation.

Many men are experts at putting things on paper, submitting figures, etc., but are sadly lacking when it comes to the working out of details. This type is not confined to the ranks of the consulting engineer by any means. I have seen operating engineers who could keep their engines running without a sign of a knock, who knew the steam tables by heart, who were experts with the indicator, and knew valve setting from A to Z, but who paid no attention to the little things. I have known these same men to run all day with the cylinder cocks open and have steam traps leaking steam for months at a time.

The expert is the man who is "onto his job"; it matters not whether he be a consulting engineer, operating engineer, fireman, or oiler. The man who is expert on the small job is the man who will be expert in a higher position.

R. L. RAYBURN.

Kansas City, Mo.

A new use for electric welding is described in the engineering supplement of the London *Times* of September 14, 1910. A steel chimney 56 feet high and 4 feet 3 inches in diameter, was put together entirely by electric welding, and was completed before erection. It was erected in about three hours.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues.

Economic Engineering

In the September 27 issue there appeared an editorial on "Economic Engineering." The article is good and furnishes food for thought, but I cannot say that I wholly agree with one statement made.

In speaking of the improvement of equipment and methods of operation the article reads: "The economic engineer is in a much better position to produce an effective solution of the problem than the superintendent or chief engineer, because with the latter it is often very hard to break away from long established customs, while the economic engineer is free from local prejudice and has a vast amount of data, collected from various other plants, to aid him in making intelligent recommendations."

I do not doubt that this may be true in a good many cases, but when the writer made this statement, I am inclined to think that he did not have in mind the superintendent or chief engineer who is "onto his job."

I have found a great deal more unwillingness on the part of employers to furnish new equipment with which to improve the methods of operation, than unwillingness on the part of operators to break away from "old established customs."

The man who is "onto his job" knows his plant from A to Z, as no other man can know it without having had experience in operating that particular plant. He knows the condition of every piece of apparatus in the plant and its relation to the economy of the plant as a whole. He has a system of records and reports and knows not only the total output of the plant, but also the power consumed and the exact hours of service of each machine under his charge. He not only knows the total output, fuel and water consumption, cost of labor, supplies, etc., but makes a study of the relation each bears to the other and to the expense of operation of the plant as a whole. He is able to tell each day exactly what the expense of operation was for the previous day.

He is always looking for new apparatus and ideas for the improvement of the service and economy of his plant. He visits other plants in search of new ideas, improves every opportunity of discussing mechanical topics with men of his own calling and eagerly scans all the mechanical papers he can get his hands on for any information which will make him a more efficient man and thus improve the efficiency of his plant.

He not only reads the mechanical papers but carefully studies the advertising pages in search of any new apparatus or ideas which may be applied to his plant.

It is easy to forget. One often forgets little things which might be used to advantage in his own plant. The man who means business generally carries a notebook in his pocket, in which he puts down every idea which there is any possibility of his being able to apply to his own plant.

R. L. RAYBURN.

Kansas City, Mo.

Accuracy of Water Meters

I have read with interest numerous articles in POWER in regard to the accuracy of water meters of the disk type.

In June, 1908, I wished to run a few boiler tests on the boilers in my charge and as we had no means at hand of accurately measuring the water for two 250-horsepower boilers, the superintendent borrowed two 2-inch new disk-type meters from a local water company. These meters were of a well known make and such as are used in water-works service. As two boilers were to be tested at once, one meter was temporarily connected to each boiler and the tests made with water at a temperature of 80 degrees, as hot water will warp the disk and make this type of meter unreliable.

After the tests (four in number) were made, the meters were taken down and calibrated in the following manner:

A barrel was placed on a platform scale and weighed, then the meter was connected up with a piece of 2-inch pipe and a length of 2-inch hose with a valve on the inlet side near the meter. A certain number of cubic feet of water was measured into the barrel and weighed at different rates of valve opening, the water being at a temperature of 80 degrees. The pump pressure was about 100 pounds. The different rates of flow through the meter were made by regulating the valve opening from one-quarter to full open. For each cubic foot of water registered by meter *A* the average weight was 65.8 pounds. The weight ranged from 63.1 pounds with the valve nearly closed to 69.3 pounds per cubic foot with the valve wide open.

The average weight per cubic foot registered by meter *B* was 69.1 pounds. The weight ranged from 66.3 to 76.8 pounds with different rates of flow. Both meters were new and had never been used before. In other instances also I have noticed the same thing, that is, that the meter does not register as much as it should, the error being from 1 to 11.5 per cent.

J. CASE.

Hyattsville, Md.

Boilers of Large Capacity

With a given firing method and a given type of boiler, the size of the boiler unit does not affect the efficiency at all; so the only argument for enormous boiler units is economy of space, and a slight reduction of first cost. But, on the other hand, an enormous boiler unit is undesirable for the simple reason that whenever a tube needs replacing, or whenever cleaning is necessary, an undue proportion of the boiler plant must be shut down. At Detroit, two gigantic boilers supply a 14,000-kilowatt turbine, so half the boiler plant is out of use whenever repairing or cleaning is required; while if four units of normal size were substituted for each of these boilers, only one-eighth need be shut down at a time.

With this type of boiler, where the entire ground space is occupied by the furnaces, and the water tubes and drums partly overhang above the firing floor, the division of each boiler into four single-ended units would make practically no difference in the amount of ground space required, not much difference in the first cost and no difference whatever in the capacity or efficiency.

Gigantic boilers units of practically identical size and design were installed in London in 1904; but such huge boiler units do not appear to have been adopted elsewhere in Europe, for the above reasons of convenience of small boiler units.

While the Stirling boilers at the Delray station, described in the issue of October 11, have curved tubes and 23,040 square feet of heating surface each, the Hornsby "Nesdrum" boilers in London have straight tubes arranged in nests, but in similar broad and shallow banks, and have 21,700 square feet heating surface each. The latter have shallower grates with only 336 square feet of grate surface and have a rated output of 100,000 pounds of steam hourly. This involves a higher rate of combustion than in the

case of the Stirling boilers which are reported to raise 130,000 pounds of steam hourly, using stokers with 480 square feet of grate surface. The London boilers were described in Mr. Patchell's paper of December 7, 1905, to the Institution of Electrical Engineers. The general opinion in the discussion ensuing was that gigantic boiler units had no advantage over normal boiler units, and nothing has occurred in the five years since to alter this opinion.

CHARLES ERITH.

London, England.

Does the Crosshead Stop?

In the October 4 issue the question is asked, "Does the Crosshead Stop?"

On page 172 of "Stevens' Mechanical Catechism" the following question and answer are given:

"Does a crosshead stand still at dead-center points?"

"No. The crosshead center could stand still only if the crank pin moved around it as the center. The accompanying figure shows how the reality differs from such a case. The points H and H_1 are the positions of the crosshead-pin center when the

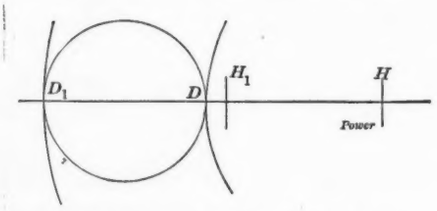


DIAGRAM OF CROSSHEAD TRAVEL

crank-pin center is at D and D_1. The circle shows the real movement of the crank pin; the two curves indicate the circles in which the crank pin would have to travel as long as the crosshead stood still.

"The movement near the dead centers is comparatively slow, but as the crank pin does not stand still at the dead center, but is moving either toward or away from it, the crosshead, moving with it, does not stand still either. The dead center is an imaginary point having no dimensions; thus it cannot be said that the crank-pin center *remains* at the dead-center point any *time* or that it takes the crosshead any time to change its direction of stroke."

The pendulum of a clock does not stand still at either end of its arc of oscillation. No time intervenes between the end of one year or month or hour and the beginning of the next.

The question I wish to ask is, if the crosshead does not stand still, how can it stop? And, how can it change direction without stopping when it has to go back on the same line that it came out on?

H. T. FRYANT.

Jackson, Miss.

Foaming in Boilers

In the issue for October 4, page 1790, it is stated that "Foaming in steam boilers is a violent ebullition which carries water in the form of foam to the steam space and main steam pipe. It can be prevented by using clean water in a clean boiler."

Is not this statement incorrect? Are there not mineral waters supposed to be clean which will cause a boiler to foam? Also, will not soft (distilled) water cause violent foaming under certain conditions?

A. L. HOOVER.

Ottumwa, Ia.

One Valve Performing the Functions of Two

As to Mr. Potter's proposed scheme for making one valve perform the functions of two, described in the October 18 issue, I would say that it is perfectly feasible, and that his diagram has the problem pretty well solved. In practice, however, he will find that it is rather difficult to keep the valve tight, unless a means of adjustment is provided to compensate for the wear on the valve and its seat. This can easily be done by making the pressure plate adjustable, which he has provided above the valve.

This is not altogether a new scheme as I have operated compound engines in which the control of all of the events in both cylinders was accomplished by means of one valve.

J. M. ROW.

Fort Flagler, Wash.

Feeding Boilers

The article by A. Rathman under the above heading in the issue of October 18 is, to say the least, misleading and the arrangement of feed pipes there mentioned is out of date, dangerous and one that would be condemned by the State inspectors and boiler-insurance companies in this part of the country. I am taking it for granted that he is writing about the ordinary return-tubular boiler. The practice in this State and the one that is compulsory according to the Massachusetts State boiler rules is "that the water must be discharged at about three-fifths the length of the boiler from the front head over the central row of tubes and below the lowest water line." This, I believe, is the correct way to arrange the feed pipes and from my experience I believe it to be the best. His arrangement, by which the water is discharged at a distance of only 2 feet from the front head, will certainly cause more or less local contraction of the shell plates and sooner or later he will have a leaky seam or cracked plate.

His statement that this is the coolest part of the boiler is, I think, wrong. If, when a boiler is under steam, there is such a condition of things that one part of the boiler is cooler than another, it surely is not the front end, for that is directly over the fire and should by all means be the hottest part.

How his arrangement can in any way have a tendency to lessen his troubles from scale I cannot see. In fact, to my mind, if he has water that deposits considerable scale he will have it in the most undesirable part of the boiler, directly over the fire, where it can do the most damage, causing the sheet to burn, bag or blister and the tube ends in the front head to leak.

Of course, I must admit that he may not have these troubles for my experience has been that results are not always what we think they ought to be. Still, the danger exists and it is good practice and common sense to guard against it. No one at the present time would think of feeding a boiler through the blowoff, that is, for a steady feed. Yet I have run boilers that were fed that way for 21 years and the boilers were to all appearances as good as they were the day they were put in operation. Circumstances favored the boilers in this case. The feed after passing through the heater was at a temperature of 210 to 214 degrees Fahrenheit, according to whether we were using any back pressure or not on the engine. All the returns from a high-pressure heating system entered the boiler through the same pipe and the temperature of the feed water on entering the boiler must have been very near or quite at the temperature due to the pressure carried on the boiler, 90 pounds. To say that this was the only correct and best way to feed a boiler would be foolish, for conditions in most plants would make it entirely out of the question.

In another plant that I took charge of there were four 60-inch by 18-foot return-tubular boilers. The feed pipe entered the boilers through the top of the shell about 10 inches back from the front head, dropped down to within about ½ inch of the tubes, branched to each side, with a pipe extending back about 2 feet toward the back head. This arrangement was put in by a "bright" master mechanic against the protests of the engineer. Very soon after being put in operation the girth seam over the furnace started to leak and no amount of calking would keep it tight. The night watchman was blamed for the trouble and all manner of schemes were tried to catch him putting cold water into the boilers during the night, but he steadfastly maintained that he used the injector at all times and never the city pressure. The following Sunday, after I had taken charge, the boiler-insurance company's inspector made me a visit. As I had been inside the boilers before he came and had seen the feed-pipe arrangement, I had made up my mind as to the cause of the trouble. The inspector's attention

was called to the feed pipe but he would not order it changed and would only suggest that a change be made. He, like the rest, was inclined to blame the night watchman and cold water. This did not satisfy me and to prove that my idea was right I ran the pipes in one of the boilers back to within about 3 feet of the back head. I calked all of the leaky seams and under a hydraulic test found everything tight. In less than two weeks the seams in the other three boilers were leaking. The one in which the feed pipe extended to the back head was tight and, in fact, is so at the present day. After this demonstration the other three feed pipes were changed and no more trouble was experienced from leaky seams.

I have seen boilers piped in all manner of ways, being fed with all kinds of water and at all temperatures. But, for me, I want the feed water to discharge in the back part of the boiler and at as high a temperature as it is possible to get it.

S. E. WILLIE.

Lowell, Mass.

Engineers' Wages

Mr. Harris' letter in the October 18 number inspires a few comments.

If there is a single employer who does not realize that money invested in a *good* man is the best investment that he can make, that employer is in the "has-been" class and it is a poor proposition to remain with him even if you bluff a raise in wages out of him by unionism or any other form of coercion.

Further, if so situated, and your present employer is short-sighted or totally blind, if he has an engineer who is one of those "Johnny-on-the-job" fellows, the fact will be advertised gratis for some distance. This kind of engineer usually has several voluntary offers of other jobs per year. Do you? Mr. Harris asks what is the standard by which men are to be measured. A man is worth the prevailing wages paid for unskilled labor until he begins to think. Then, his thoughts are not worth thinking about until he begins to practice. Then, his practice is not worth much until he begins to *get results*. Then, his boss usually gets busy at the pay-envelop end before some other employer gets his man.

Will Mr. Harris cite an instance where a union organized to better conditions, including the wage scale, ever improved anything except the wage scale of the mediocre workman?

Trusts, corners or any other illegal combinations in restraint of trade are apt to be profitable to those who make them successful, that is, generally, the promoters, not the "suckers." But they are generally held in contempt, lately, and seldom referred to as things whose virtues are to be emulated. Then, let us not express a desire (even if we feel it) to imitate what our Government is even now busy prosecuting. It really does not sound nice to say, "Come on, let us do something the doing of which threatens others with iron bars and gloomy walls, and let us do it in just the same way in which they have done."

I really believe that if I had been a member of a labor union when I read Mr. Harris' article I should have withdrawn my membership. I have heard that labor unions disclaim any connection with violence, and say that such is the work of thugs, in no way interested in their cause. In fact, I have read the statements of officers of unions wherein they say that no friend of their union would do anything to reflect on the union and I have believed that they were sincere.

Mr. Harris certainly does not voice the sentiment of the majority of the readers of POWER. Many prefer to feel that they have *earned* what they get, not extorted or coerced it.

W. R. SMITH.

Alton, Ill.

Boiler Feeding by Centrifugal Pumps

Referring to the editorial in the October 11 issue of POWER on "Boiler Feeding by Centrifugal Pumps," it appears to me that this is very timely, inasmuch as American engineers do not seem to appreciate the advantages of the turbine-driven centrifugal pump for boiler-feeding purposes. However, there is one statement, on the use of boiler-feed regulators, to which I wish to take exception.

It is stated that "If a feed-water regulator is used, as is common in large plants, the speed of the pump is automatically controlled, but when the speed of the pump is reduced the amount of steam entering the feed-water heater is also cut down, and the water enters the boiler at a lower temperature."

From the quotation it is evident that the proposition in mind concerns a feed-water heater using only the exhaust from the boiler-feed pumps, but the fact seems to have been lost sight of that "when the speed of the pump is reduced," less water is being pumped through the heater. It is therefore evident that the amount of steam exhausted by the pump into the feed-water heater fluctuates exactly in proportion to the amount of water handled, and therefore the feed-water regulator tends to maintain a practically *constant* temperature.

In practically all power plants there are other pieces of auxiliary apparatus, such as circulating pumps, mechanical-draft fan engines, exciter engines, etc., besides the boiler-feed pump which exhausts into the same feed-water heater. Now, when an overload comes on, some of this auxiliary apparatus is also subject to a greater load and consequently more exhaust steam enters the heater. This overload at the same time makes it necessary to feed the boilers faster in

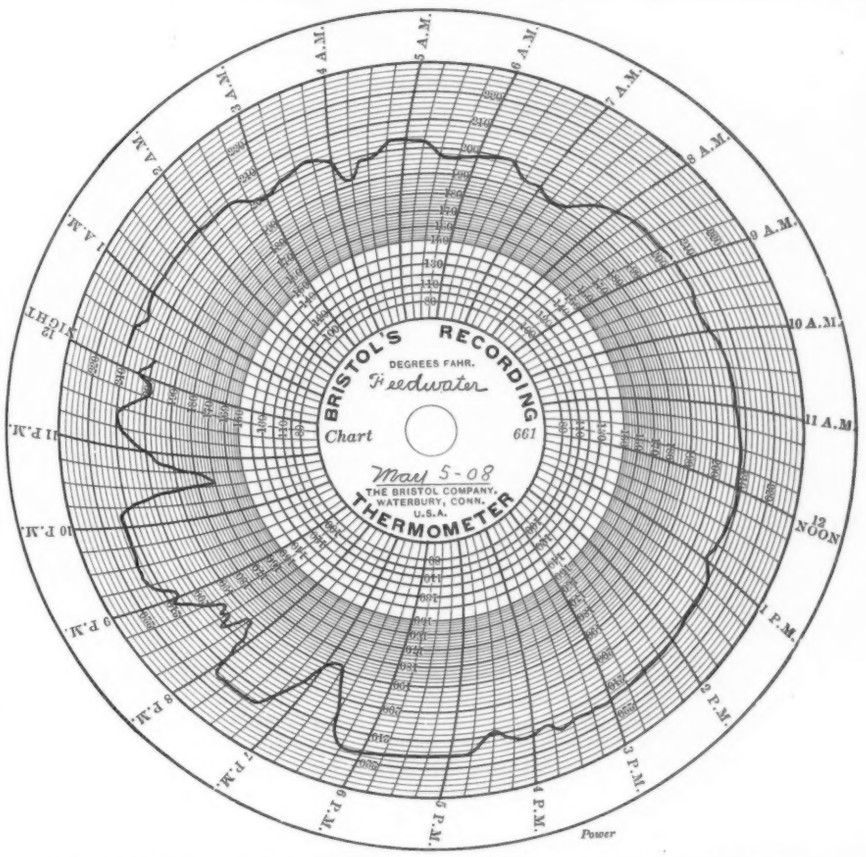


FIG. 1. FEED-WATER TEMPERATURE WITH MANUAL CONTROL OF FEED VALVE

order to maintain the correct level, the latter being automatically looked after by the feed-water regulator. Thus, the feed-water regulator always tends to keep the amount of water going through the heater proportional to the amount of steam in it. These are conditions which, of course, tend to higher final temperature.

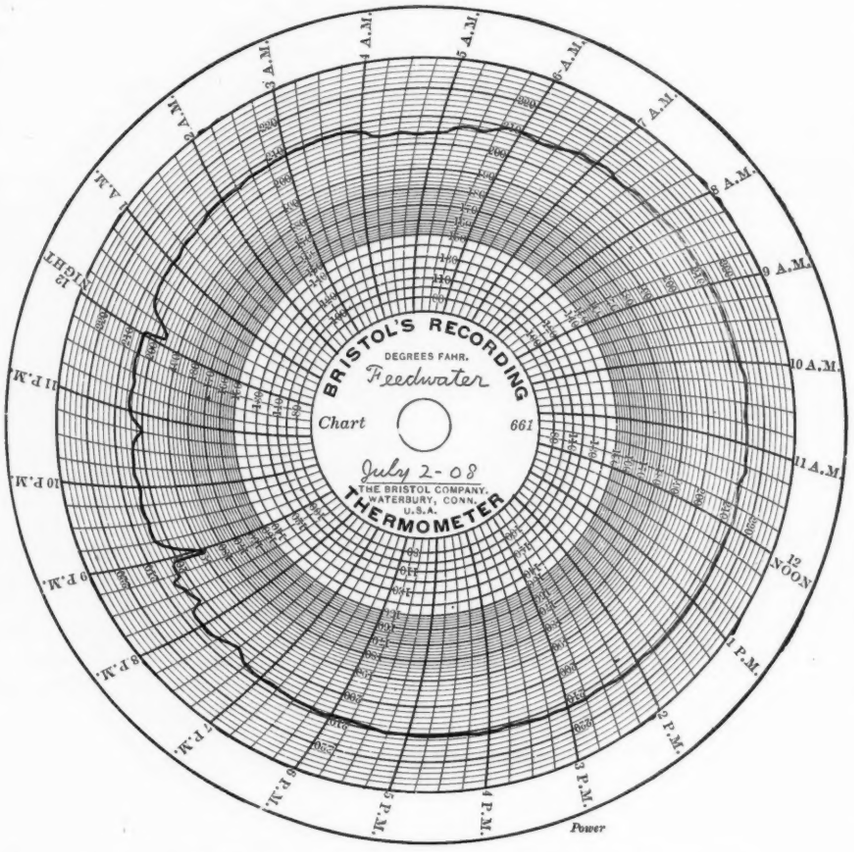


FIG. 2. FEED-WATER TEMPERATURE WITH AUTOMATIC REGULATOR

The above points are perfectly evident on theoretical grounds but are also demonstrated by actual operation. Figs. 1 and 2 are temperature charts for a feed-water heater. Fig. 1 shows the exit temperature of the water when the boiler-feed valves were operated by hand. Inasmuch as an attendant never operates the feed valve directly in proportion to the rate of evaporation in the boiler, there are times when the valves are opened wide and the water passes through the heater at a much greater rate than that demanded by the load; thus the feed-water temperature under these conditions is low. If the feed valve is then nearly shut off, the auxiliary apparatus still supplies steam to the heater, but as only a small amount of water passes through it the temperature becomes excessively high. This is exactly what is shown by the chart.

Fig. 2 shows the temperature readings from the same feed-water heater when the boilers were equipped with boiler-feed regulators. It is readily seen that the regulator acts in such a manner that the feed-water temperature is maintained very nearly constant. By integrating these two curves I have also found that the average temperature in the second case is nearly five degrees higher than in the first, which amply supports the statements just made. An average increase in temperature of the feed water of five degrees means a fuel saving of about ½ per cent., which, when figured out for a year, shows a substantial sum of money saved.

GEORGE F. FENNO.

New York City.

Size of Reducing Valve Required

In the October 18 number, G. S. Sprague asks advice regarding the size of reducing valve to install in a steam-heating system.

I agree with him that a 2-inch valve would be about right. With a 2-inch bypass, which should be put in to supply steam in case it should be necessary to make repairs on the reducing valve, the bypass can be used in case more steam is required than the reducing valve is capable of supplying. We have our system arranged in this manner, and frequently use the bypass on cold nights when there is little exhaust steam.

W. O. PERKINS.

Bristol, Conn.

Water in the Ashpits

The question of using water in boiler ashpits, raised in the issue of October 18, is a much broader subject than would appear at first glance. The practice is not new and has been in use for many years both in stationary plants and in marine practice.

What are the advantages? In marine boilers located on boats such as harbor tugs, lighters and boats of that class, the advantage of having water in the ashpit lies primarily in the fact that in the removing of ash it eliminates dust. In the majority of boats dust can do more damage in wear and tear on the machinery than the actual work of operation, and in boats of the class above referred to the engine is frequently located adjacent to the boiler where dust from it would be a costly nuisance.

Using water in the ashpits of boilers located on land has no special general indorsement. If hard coal is used, the present standard grades of which usually contain from 5 to 10 per cent. of moisture, water in the ashpit has no beneficial effect.

Of the soft coals there are classes which might be slightly benefited by the usage of water in the ashpit, but it would largely depend on the type of grate bars on which the coal was burned as to just what that benefit would be.

My own theory of how this practice originated on land is that it is either a copy of the usage of water in ashpits of steamboats, or that it is done with the idea of merely killing the live ash as it works through the grate thus preventing the heating of the grate bars on the under side, to their detriment.

One theory of the usage of water lies in the reduction of clinker, and is copied from the feature of using steam blowers in the ashpit, which has been found to eliminate objectionable clinker and at the same time accelerate draft.

It would be quite an argument to prove that the presence of water in the ashpit gave any considerable portion of moisture to the air supplied to the grates, if dependent solely upon the water being picked up by the air in its transit from the ashpit door up through the grate bars. If, however, a very open grate bar were used and the fires worked down, the live ash dropping into the water would produce steam which would have more or less effect on the clinkering of the coal and might produce to some extent the same result that a steam blower would.

The value of using water in the ashpit, therefore, is affected by the quality of the coal burned, the grate bar used and by the thickness of the fire carried on the grates, and is also somewhat affected by the draft conditions. I believe its advantage or disadvantage to a plant could only be proved by actual tests carefully

carried out. If any water is to be used I would suggest that the following features be carefully studied:

If water is put in the ashpit it should not be to a greater depth than one or two inches. The ashpit should be properly prepared so that the presence of water in it will not affect the brickwork or settings of the boiler. Its preparation should consist in having the entire pit lined with not less than one inch of first-class concrete extending as high as the bearing bars. If this is not done the water will work into the bricks of the setting and deteriorate them and the mortar in which the bricks are set.

If it be an iron setting, such as is found in some of the self-contained boilers, all of the iron should be carefully covered with the cement lining above cited, as ash and water together cause an action which will effectually injure the iron in a very short time.

CHARLES H. PARSON.

New York City.

Corn Cobs as Fuel

In response to the request in the October 18 issue for information as to burning corn cobs under boilers, I see no reason why anyone should not burn cobs with as little injury to the boilers as with coal. I have burned lots of them without bad results of any kind.

They make a quick, intense fire, which does not last long. Regulation of such a fire is best accomplished by restricting the inflow of air by keeping the ashpit doors properly adjusted, thereby obtaining a steady heat with less liability of damage to the boiler due to sudden changes of temperature such as would occur with excessive air openings in the ashpit.

I favor the ashpit regulation in the case of cobs, natural gas and shavings, more than with coal, for there is more danger of buckling the fire sheets with those fuels. With a boiler experience of 30 years and having handled most every kind of fuel, I have never had a bagged or corrugated boiler bottom. I attribute my good luck in this respect to keeping the boiler clean inside.

In burning cobs the grates will, if the firing is strong, become covered over in a day's run with a tough leathery slag that adheres tenaciously to the grates and can hardly be removed until cold.

S. E. EVANS.

Anderson, Ind.

In answer to the Western correspondent's query about burning corn cobs and slack coal together, I can give the results of 14 years' experience. My first 4 years of firing was with cobs alone and after that, cobs mixed with Jackson Hill and Hocking slack. The tubes were cleaned once a week and the ashes cleaned out of the back end of the boiler once a month. Very seldom was more than an ordinary wheelbarrow load taken from the grates for a 10 hours' run. Forced draft was used some of the time owing to a short stack. No damage has been done that we can discover that can be laid to anything but ordinary wear and tear.

The cobs make a good hot fire and it is not necessary to use a bar with clear cobs, and very seldom with cobs and coal. This is quite a corn country and in the few steam grist mills that are left they burn all the cobs that they can get.

H. M. ROWLEY.

Adrian, Mich.

About 14 years ago I worked in a plant where they fired four boilers with 75 per cent. cobs and 25 per cent. slack coal. With the kind of coal we were using, it would have been impossible to generate the required amount of steam without the cobs.

About eight years ago I took charge of a plant that had five 125-horsepower boilers, under which mine-run coal costing $1.50 per ton was being used. The cobs were being burned up in the open, for the owners were of the same opinion as our Western friend—that the cobs would ruin the boilers. I commenced using cobs and slack coal, for which we paid 80 cents per ton; a mixture of half cobs and half coal was used and after the firemen got used to handling the cobs and coal they could keep up the required pressure easier with the coal and cobs than they could with the mine-run alone.

During a miners' strike, lasting six months, we fired with nothing but cobs. In all of my experience in using cobs as a fuel I have never noticed any injurious effects to either the boiler shell, tubes or settings that I thought was caused by using the cobs.

Cobs are a little harder on grate bars than coal alone, but by keeping the ashpit well filled with water, one can offset this.

J. W. VARDEN.

Evansville, Ind.

Other letters were received on the subject of "Corn Cobs as Fuel." In all of them the opinions expressed were substantially the same as those in the letter published herewith. The writers of the unpublished letters are, S. Kirlin, New York City; R. A. Cultra, Cambridge, Mass.; W. A. Field, Anoka, Minn., and C. A. Moore, Piqua, O.

Valves and Packing to Withstand Acid

Referring to Mr. Demarle's inquiry in the October 18 issue under the above heading, I would say that probably the best results could be obtained by substituting lead valves for rubber. Valves made from lead are soft enough to prevent leakage and at the same time are very little affected by acids. For the pistons in the acid ends of the pumps either lead rings or metallic packing could be used. This metallic packing, which is shredded babbitt metal mixed with graphite and oil, could also be used to advantage in the stuffing boxes.

JOHN FRENCH.

Washington, D. C.

Jealousy and Plant Management

I agree with B. P. Gage's sentiments as expressed in his letter in the October 25 issue under the title "Why Are There Not More Writers among Engineers?" It would seem as though older engineers, by not giving younger ones the benefit of their experience, display unreasonable jealousy.

The following incident serves to illustrate the point. A fireman who was young and ambitious to progress, once asked the assistant engineer on his watch what the number of stages was of a certain air compressor in the plant. The engineer said that it was a four-stage machine. The fireman, not being entirely ignorant on the subject, doubted the accuracy of the engineer's statement and when a favorable opportunity occurred he put the same question to the chief engineer who told him that it was a two-stage compressor.

Mr. Gage inquires about handling men. I will give him the benefit of the experience I have had during five years' service in the United States Navy. I am convinced that in any plant of whatever size a fixed system should be evolved and put into effect. Perhaps the following may meet with approval:

1. Every man must be at his post ready for duty on time.
2. Waste, oil and grease to be issued only on order from the assistant engineers as required for their shifts.
3. Every man, from the first assistant engineer down to the oilers in the engine room, and from the head fireman down to the firemen in the boiler room, to have a definite amount of bright work, steel work, floor area, etc., to be cleaned by a certain hour each day for inspection by the chief engineer.
4. Keep records for each day, showing the quantity of coal and water used, the nature of all repairs made and the quantities of supplies issued.
5. Liquor to be allowed in the plant under no circumstances.
6. Each man to inform his relief as to the condition of the apparatus under his care and a description of any repairs that may have been made.

The chief engineer should have no "pets." The work should be divided with fairness and all orders should be obeyed.

W. G. VEDDER.

Fort Logan, Colo.

Boiler Explosion at Mount Victory, O.

By Osborn Monnett

Explosion of sawmill boiler of portable locomotive type, which had long outlived its usefulness, killed four men. The metal was badly crystallized. Boiler was of size not covered by Ohio inspection laws.

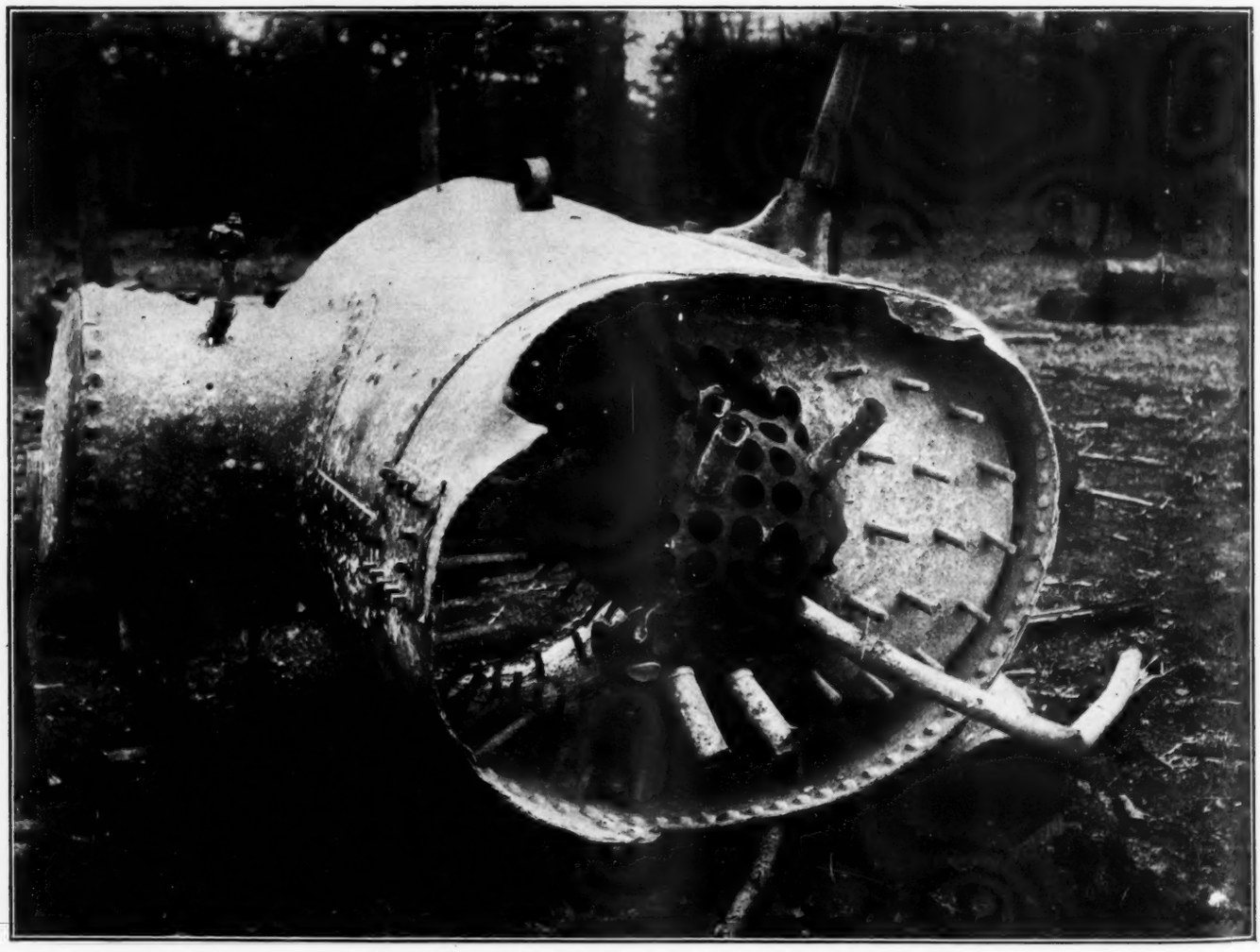
An old sawmill boiler exploded about noon, November 11, on a farm 5 miles southeast of Mt. Victory, O., a small village in the west-central part of the State. The boiler was of the portable locomotive type mounted on wheels, the axles being bolted direct to the shell at the firebox end. The engine was mounted on the boiler shell and was of the throttling type with semi-rotary valves.

The owner, who was also the engineer, had shut down for the noon hour, and on departing for a farm house ½ mile distant for lunch, remarked to one of the workmen about the mill that there was an unusually hot fire in the firebox and asked that those remaining at the mill to eat lunch keep watch of the water in the boiler.

The owner had just returned from lunch when the explosion occurred, killing him and three others. Several men who were returning to the afternoon work report that at the instant of the explosion they could see at a distance one of the mill hands pouring water upon the injector, indicating that they had experienced trouble in getting water into the boiler.

It is presumed that the water got low, overheating the crown sheet and causing the explosion. The latter, as shown in the accompanying illustration, collapsed, every staybolt pulling out at the threads. The staybolts, which were 7/16 inch in diameter, were badly corroded and at a point about corresponding to the water line had wasted away to about one-half their original area. The bolts did not let go at this point, however, but pulled out at the threads in every instance. There was no soft plug in the crown sheet and no provision had ever been made for one.

The front head (firebox end) of the boiler was blown out clean, and the barrel of the boiler tore completely around its circumference at a point near the throat seam, being thrown in an opposite direction to that of the head. The boiler was fitted with a 1½-inch safety valve of the pop variety, which, on examination after the accident, was apparently in good condition, no evidence of corrosion being seen. The metal of the boiler was in a badly crystallized condition, and where the sheets were torn, laminations of the metal were easily discernible. The outfit had been obtained second-hand by its last owner. The metal in general was in the most wretched condition and apparently the entire outfit had long outlived its usefulness. This boiler was of a size that does not come within the regulations of the Ohio license laws and emphasizes the need for closer supervision of steam boilers and operators of these portable outfits.



FIREBOX END OF BOILER, SHOWING COLLAPSED CROWN SHEET

Proposed Changes in Mass. Boiler Rules

By Benjamin Baker

A lively and at times somewhat acrimonious hearing took place before the Massachusetts Board of Boiler Rules at Boston, November 3, on a petition from certain boiler manufacturers of the State asking for certain changes in the present rules. The proposed changes were as follows:

It is proposed to omit the words in *italics* and to insert those in **black face.**

No. 1, page 47, paragraph 67. A horizontal tubular boiler over seventy-eight (78) inches in diameter (*shall*) [**may**] be supported independent of the boiler side walls from steel lugs by the outside suspended type of setting. Where three (3) supports are necessary on each side of a boiler, an equalizer shall be used.

No. 2, page 40, paragraph 32. A horizontal return-tubular boiler, having a manhole below the tubes, shall have one or more stays on each side of the manhole, the rear ends of which shall be attached to the rear end of the boiler, and the front end shall pass out through the front head and shall be secured with nuts inside and out. (*The center line of such stays at the front head shall not be below the center line of the manhole*) [**or the front end of the stays may be attached to the front head in a similar manner as to the rear head.**]

No. 3, page 46, paragraph 60. (*A manhole shall be located in the front head below the tubes of a horizontal return-tubular boiler sixty* (60) *inches or over in diameter*).

[**The placing of a manhole in the front head below the tubes of a horizontal return tubular boiler shall be optional.**]

No. 4, page 21, paragraph 5. The rule states that the tensile strength in pounds per square inch of firebox steel shall be from 52,000 to 62,000. The amendment proposes to substitute the figures 55,000 to 65,000.

No. 5, page 21, paragraph 3. "There shall be three classes of open-hearth boiler plate and rivet steel; namely, flange or boiler steel, firebox steel and extra-soft steel, which shall conform to the following limits in chemical composition." The suggested amendment recommends that no quality of steel shall be used of a less composition than that required of fireboxes, or that the rule be so amended that on and after January 1, 1912, no flanged steel shall be allowed in any plate or head of a boiler.

No. 6. Suggests amending the same paragraph by making the acid steel contain only the same amount of phosphorus as the basic process.

No. 7, page 12, paragraph 1, section VI. When a boiler is tested by hydrostatic pressure, the maximum pressure applied shall not exceed one and one-half (1½) times the maximum allowable working pressure, except that twice the maximum allowable working pressure may be applied on boilers permitted to carry not over twenty-five pounds pressure per square inch, or on pipe boilers.

[**the minimum pressure shall be one and one-fourth (1 1/4 times the working pressure.**]

No. 7, page 31, paragraph 4. The section, which is too lengthy and involved to quote, relates to the staying of boiler heads by the use of angle irons, and the amendment suggests the addition of examples or rules for 125 and 150 pounds pressure both for the 30- and 36-inch boilers.

No. 9, page 48, paragraph 9. The feed water shall discharge about three-fifths (⅗) the length of a horizontal return-tubular boiler from the front head (except a horizontal return-tubular boiler equipped with an auxiliary feed- water heating and circulating device), and at about the central row of tubes above the tubes when (*the diameter of the boiler exceeds thirty-six* (36) *inches, and*) the pressure allowed exceeds twenty-five (25) pounds per square inch. The feed pipe shall be carried through the head or shell with a brass or steel-boiler bushing, or the opening reinforced, and securely fastened inside the shell above the tubes.

this rule does not apply to boilers thirty-six (36) inches and less in diameter.]

No. 10. Also advise the best method of feeding water into boilers of thirty-six (36) inches in diameter and less when made for working pressures exceeding twenty-five (25) pounds and not having a manhole.

It appears quite certain that the first four amendments and also Nos. 7 and 8 will not be adopted by the board. Articles 5 and 6 met with no opposition from any source, and are not unlikely to be adopted. Articles 9 and 10 are aimed chiefly at more definitely defining the required practice in order to end some slight controversies over the interpretation given by the inspectors of the board to the rules.

The interests of the operating engineers and the outside public were effectively presented at the hearing by representatives of the National Association of Stationary Engineers and the International Union of Steam Engineers.

The hearing opened with a lively discussion as to just what interests were represented by the petitioners. It was finally made clear that the changes were asked for by a committee of five, consisting of one member from each of the five large boiler-manufacturing firms in Massachusetts. The New England Boiler Manufacturers' Association in April, 1909, appointed a committee on boiler rules; this committee in turn appointed as a subcommittee, with full power to act on the Massachusetts rules, the five members of Massachusetts firms who represented the petition given above.

It was made clear therefore that the petition represented the wishes merely of five Massachusetts manufacturers, and that the suggested changes did not have behind them the authority of the New England Boiler Manufacturers' Association.

No technical reasons were presented by the petitioners in support of the first three changes. For the first amendment the only reason advanced was that in a few cases the requirement of the outside suspension type of setting had made it impossible to enlarge a boiler plant without moving one or more of the existing boilers. The operating engineers present objected to any weakening of the present rule for mere reasons of convenience such as were presented.

In favor of the second change the only reason was the asserted fact that certain engineers designed boilers with the lower tubes in such relation to the manhole that the stays had to be put below the center line of the manhole, a practice which is forbidden by the Massachusetts rule. Discussion very quickly brought out two strong points against the amendment; first, that a lower position of the stays than that now required would weaken the boiler head, and second that the adoption of the amendment as to the method of attaching the stays to the front head would leave the rules entirely without specification as to the manner of fastening at either head.

Strenuous opposition from the operating engineers was aroused by amendment No. 3. It was argued by the engineers that a manhole in the front head below the tubes of large tubular boilers is absolutely essential to proper inspection and cleaning of the interior of the boiler; and was required for the safety of both the operating men and the general public. On this question, Mr. Stevens, of the board, representing the boiler-using interests, referred to articles on boiler explosions in the November 1 issue of POWER, which he called the leading engineers' paper of the country. Mr. Stevens declared that the chief article of faith of the operating engineer was that boiler safety lay in the engineer's ability to inspect every part of the boiler inside and out. The adoption of amendment No. 3 would remove from the rules so much of the guarantee of safe operation as is secured by the existence of such manholes in large boilers, and of

the internal inspection which these manholes permit.

On the question of raising the tensile-strength limits merely for firebox steel, the main reason in favor of the proposed change appeared to be the fact that the steel mills sometimes found it inconvenient to meet the limits, 52,000 to 62,000 pounds, imposed by the present rules. Mr. Stevens, of the board, referring to a recent visit he had made to some of the Krupp mills at Essen, reported that the new German Blue Book of boiler rules, applying to boilers for all pressures, set a maximum tensile-strength limit of 56,000 pounds. German practice had shown, it was said, that in boiler plates of higher tensile strength there was a dangerous liability to cracking. Mr. Stevens also referred to the practice of the Babcock & Wilcox Company in adopting 56,000 pounds as the maximum tensile strength used in calculations.

Under the present Massachusetts rule the tensile strength of plates as they are actually turned out by the mills ranges from 56,000 to 60,000 pounds. German practice is somewhat more rigid than that of Massachusetts; and it appears that the tendency of the best practice is to preserve a sufficient degree of ductility by limiting the tensile strength.

Amendments 5 and 6 while they preserve certain opportunities to boiler manufacturers, are in the direction of securing better material for boilers. At present, basic steel is used almost exclusively in Massachusetts boiler manufacture for the reason that it is very difficult to produce acid steel with the low phosphorus and sulphur content, 0.04 in each case required by the rules for firebox steel. Occasionally, however, and a specific example was presented from the experience of one of the petitioners, a boiler designer will specify acid steel with the low phosphorus and carbon content required of firebox steel. In bidding on such specifications one manufacturer sometimes has acid plates of the required quality, and the amendment was designed to give such manufacturer the advantage in bidding to which he was entitled by his having a particular steel specified, especially since the specification of this particular acid steel gives a plate as high in quality as the grade of firebox steel provided for in the existing rules.

Amendment 7 was not favored by the operating engineers, and; in fact, little or nothing was advanced in support of the change. The present rules prescribe no minimum; and the use of a hydrostatic test at all is left to the judgment of the State inspectors. It was pointed out that the proposed minimum pressure was so much higher than the allowable working pressure on many boilers that might be tested, that the application of the proposed minimum test pressure might cause weakness in the boiler that would be recognized only after this weakness had caused an accident.

Amendment 8, if adopted, would have the effect of making the rules accept internal angle bracing for the heads of boilers above the tubes when the working pressure is as high as 150 pounds. The rules now limit the use of such bracing to boilers not over 36 inches in diameter and with a working pressure not over 100 pounds. The board holds that such bracing is not adequate on large boilers at higher pressures than 100 pounds; since angle bracing is used only on boilers which are without manholes, and which, therefore, do not permit of internal inspection.

Amendment 9 was professedly aimed at removing certain variations in the way the State inspectors interpret the existing rules; but the adoption of the amendment, which is quite unlikely, would remove from the rules the present requirement that "the feed pipe shall be carried through the head or shell with a brass or steel boiler bushing (or the opening reinforced) and securely fastened inside the shell above the tubes." Comment by a member of the board showed that the board would not permit the removal of this part of the rule, since without it feed pipes might be made to depend for support wholly on the threads of an opening in the head or shell—a scheme which is considered inadequate.

Amendment 10 seeks an expression of opinion from the board as a guide both for the makers of boilers and for the inspectors in the case of boilers of smaller diameter than 36 inches; these are not now specifically covered by the rules.

Large Pumping Engine for Wheeling

There has recently been completed, in the shops of Allis-Chalmers Company, one of the most interesting pumping engines ever built. In point of power it practically equals the largest, that built by the same company for the city of Nashville.

The new engine is for the city of Wheeling, W. Va., and is of the vertical triple-expansion crank and flywheel type with steam cylinders 42, 74 and 110 inches in diameter and water plungers 33 inches in diameter. The low-pressure cylinder is the largest cylinder ever used on a pumping engine. The cylinders are all steam jacketed. Steam for the jacket of the high-pressure cylinder is bypassed around the admission valve. That for the intermediate and low-pressure cylinders is taken from the first and second receivers respectively. The steam from the jackets of the high-pressure and intermediate cylinders is trapped into the second receiver and does useful work in the low-pressure cylinder.

Admission valves on the high and intermediate cylinders and the exhaust valve of the high-pressure cylinder are of the Corliss type while the exhaust of the intermediate and both admission and exhaust of the low-pressure cylinder are of the poppet type. The valves are driven from eccentrics on a lay shaft supported on brackets on the main frame of the engine. This lay shaft is driven by drag cranks and connecting rods from each end of the main shaft.

The engine is of the vertical triple expansion crank and flywheel type with steam cylinders 42, 74 and 110 inches in diameter and water plungers 33 inches, the low-pressure steam cylinder being the largest ever used on a pumping engine.

The engine is designed for a steam pressure of 125 pounds and a vacuum of 27 inches. The stroke is 72 inches and at the regular speed of 18⅓ revolutions per minute the piston speed will be 220 feet per minute. Two flywheels, each weighing 90,000 pounds, are provided. The condenser is of the surface type and is located in a bypass of the discharge line of the pump with cutoff valves on either side. The engine is provided with a free exhaust for use when necessary. The condenser pump is driven from an arm on the low-pressure plunger.

The valve chambers are 72 inches in diameter, which are the largest ever built, and are of cast steel. The pressure chambers are also of cast steel. The valve deck is steel and the 186 valves in each chamber are placed directly in the deck without the use of cages. The valves are of a special weighted type which obviates the need of springs.

The water end of the pumping engine is self-contained and self-supporting. The steam cylinders are supported on double A frames, one end of which rests on the water ends and the other on a pier. The pit in which the water end is located is 46 feet deep and the total hight of the engine from the base of the water end to the top of the steam end is 84 feet 8 inches.

Each piston has a single piston rod which connects with a cast-steel crosshead into which it is screwed and held by a lock nut. Four steel distance rods

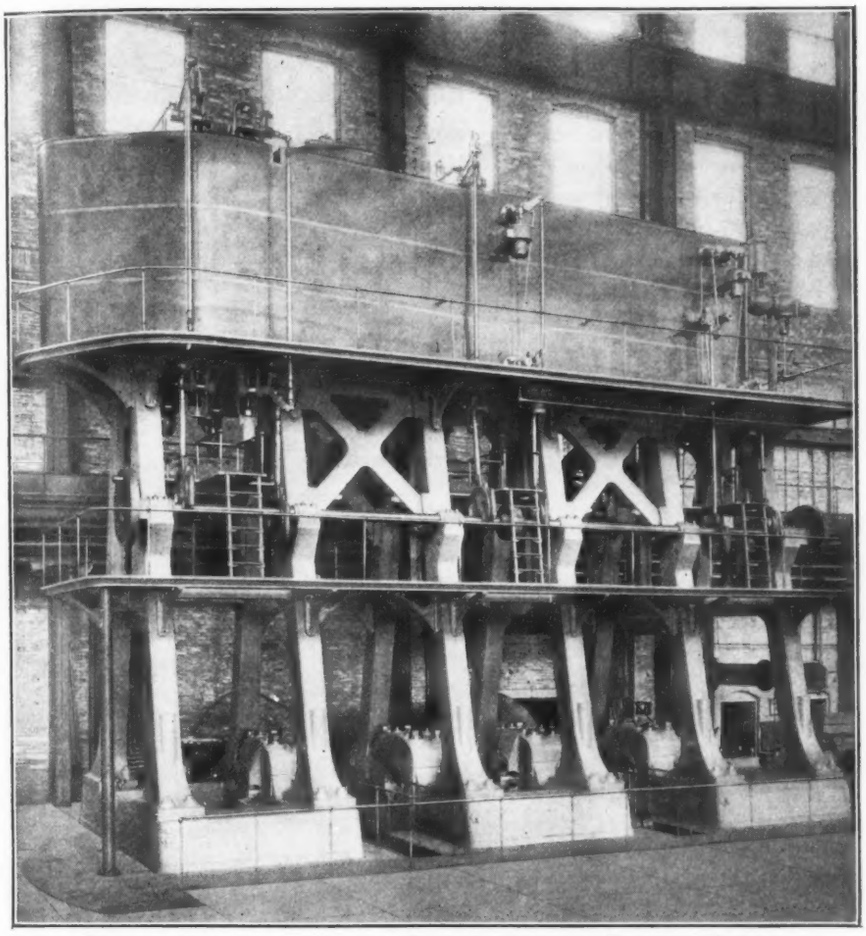


FIG. 1. STEAM END VERTICAL TRIPLE-EXPANSION PUMPING ENGINE

connect the steam crosshead with the water crosshead which is of cast steel. This is connected to the water plunger by means of heavy cast-iron pipe sections fitted with adjustable guides.

Galleries are provided at the level of the valve deck and at the plunger chambers in the pit. Above the engine-room floor are two main galleries. The lower gives access to the crossheads, eccentrics, etc., while the upper allows inspection of the valve gear and permits the use of the indicator motion. The tops of the cylinders are connected by platforms for reaching the upper poppet valves.

Hen Simpkins, th' ingineer uv th' creamery, got a overdose uv buttermelk an' sez he'z swore off. Wun uv th' schule marms kum in ter his ingin room last week an' after she'd watched th' dashpots uv th' ingin jumpin' up an' down fer awhile she pinted at 'em an' ast Hen how it wuz posserbil fer them t' make so much butter with jist them two little churns.

Hen wuz so gol darnd flabbergasted thet he tipped over backards an' fell inter a tank full uv buttermelk. He says he ain't hed any hankerin' fer th' dumd stuff since, an' thet ever time he sees a woman headin' fer th' ingin room it gives him a chill.

Third International Congress

The second international congress of the refrigerating industries, which has just closed a successful meeting at Vienna, Austria, decided to hold the next, or third international congress, in the United States, in 1913. This will offer a great opportunity to all those in the United States who are interested in closer commercial relations with other countries in those products that are best handled at low temperatures. It will enable them to meet experts from many foreign countries, and probably many representatives of foreign governments.

It will enable the refrigerating engineers and experts in this country to meet men engaged in similar pursuits in other countries, and learn from them in what way many of the ordinary or extraordinary difficulties in the construction and operation of refrigerating plants are met or overcome in other lands. It will offer opportunity to exchange experiences with those who have studied refrigerating problems from standpoints somewhat different from those which obtain in America.

The burden of responsibility for suitably entertaining the refrigerating experts of the world is no light one. However, so many departments of commerce and industry are directly or indirectly interested in the science and practical application, in one form or another, of artificial refrigeration, that assistance from most branches of industry may be expected.

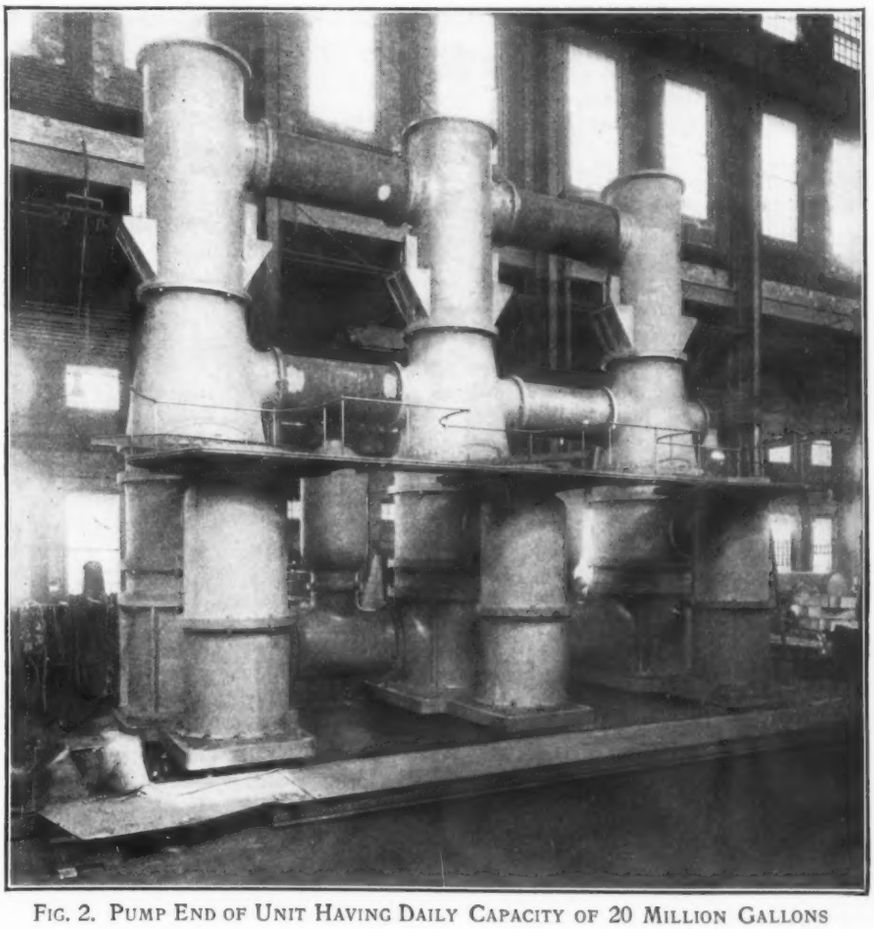


FIG. 2. PUMP END OF UNIT HAVING DAILY CAPACITY OF 20 MILLION GALLONS

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it.

Duplex Pump Valve Setting

What effect will increasing or decreasing the amount of lost motion in duplex-pump valves have on the action of the pump?

D. P. S.

Increasing the lost motion lengthens the piston stroke and reducing the lost motion shortens it.

Compression in Fitchburg Engine

How can the compression at one end of the stroke of a Fitchburg engine be altered, and how are the exhaust valves attached to the valve stem?

C. F. E.

The degree of compression may be varied by giving more or less lap to the valve on the end of the cylinder where the change is desired. The valves are loosely fitted to the stem and are held in position by a nut. The crank-end valve abuts against a collar on the stem and its position may be altered by means of washers between the collar and the valve. The head-end valve is separated from the other by a distance piece and is also adjustable along the stem by means of washers.

Setting Safety Valve

If a safety valve is set to blow at 100 pounds pressure and it is desired to have it blow at 75 pounds, what is to be done?

S. V.

With spring-loaded safety valves a slight change in the release pressure may be made by a change in the spring tension. But a change from 100 to 75 pounds will necessitate changing to a spring suitable for the pressure. With a lever valve the weight may be moved nearer to the fulcrum.

Distance of Grates from Boiler

Can you give me any rule for finding the proper distance between the grate and the shell of a horizontal return-tubular boiler?

D. G. B.

The proper distance between the grate and the shell of a boiler depends upon the nature of the fuel burned, but it should in all cases be enough so that complete combustion can take place without the flames striking the comparatively cold boiler sheets.

With anthracite coal the ordinary return-tubular boiler setting is approximately correct; but where bituminous coal is used, the distance between the grate and the boiler should not be less than the diameter of the boiler.

Efficiency of Joints

On page 2002 of the issue of November 8, an inexcusable error was made in the reply to the question on the efficiency of a single-riveted lap seam. In giving the answer it was thoughtlessly assumed that the shearing strength of the rivets was equal to the strength of the plate between the rivet holes and the general formula applied. With a shearing strength of 42,000 pounds per square inch of rivet area the strength of the rivets would be

$$\frac{0.518 \times 42{,}000}{3.5 \times 0.375 \times 55{,}000} = 0.287$$

or 28.7 per cent. of the strength of the uncut plate.

Brass Polishing Paste

Will you please give me a recipe for a good brass polish?

B. P.

A very good brass polish is made by mixing rotten stone and soft soap or sweet oil into a thick paste. Apply with a woolen rag and rub vigorously.

Water Hammer

What is water hammer?

W. H.

Water hammer is the violent projection of a body or slug of water against the end of a pipe or fitting, or against the inside surface of a boiler or receiver. It is usually occasioned by the condensation of steam in some part of the system and the violent rush of steam and water from other parts of the system to fill the void caused by condensation.

Difference in Gage Readings

In an air-tight tank full of water under pressure with gages at the top and bottom, which will indicate the greater pressure, the top or the bottom one?

D. G. R.

The gage at the bottom of the tank will indicate a pressure of 0.432 pound more than the upper one for each foot of difference in hight.

Cause of Reduced Pump Speed

Why is it that after overhauling and repairing the boiler-feed pump, I fail to get as high a speed as formerly?

R. P. S.

If your pump runs slower than it did before overhauling, it is because it is working against more resistance. This may be due to either too tight a piston, or to the fact that the piston fits well enough so that some of the water does not leak past it but all goes to the boiler.

Slipping of Main Belt

If the main belt slips on one of the pulleys will the engine require more steam to do the work?

S. M. B.

If the resistance against which the driven shaft revolves is not increased, the engine will require less steam, because it is doing less work.

Decimal Reduced to a Common Fraction

How may a decimal be reduced to a common fraction?

D. C. F.

Write the decimal as the numerator of a fraction, the denominator of which is 1, followed by as many ciphers as there are digits in the decimal and reduce to the lowest terms. For example,

$$0.375 = \frac{375}{1000} = \frac{3}{8}$$

Smokestack Dimensions

What should be the diameter and hight of a smokestack for three horizontal tubular boilers 6x18 feet?

S. S. D.

From such meager data only a general answer can be given. If the stack has a cross-sectional area one-seventh that of the grate and a hight 25 times its diameter, it will approximate the dimensions established by good practice. The grate area for a 6x18-foot boiler will be nearly 33 square feet, say 98 square feet of grate surface for the three boilers. This would give 14 feet for the cross-sectional area of the stack. The diameter of a circle of 14 feet area is 4.2 feet and

$$4.2 \times 25 = 105 \textit{ feet},$$

the hight of the stack.

Oil under Changes of Temperature

Is there any lubricating oil that will not grow thick in cold weather?

O. C. T.

So far as is known there is no oil that will not change in consistency under extreme ranges of temperature.

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POWER and The Engineer

Editorial

Depreciation

Into the cost of running a power plant there enter a number of items which, like the salesman's new suit in his expense account, "are there but you can't see them." You can see the coal going in, and you know you have to pay for that, and for oil and waste and labor and repairs, and, perhaps, for water. The office knows, if the engineer does not, that taxes and insurance have to be paid upon the power plant, and that the greater the cost of the plant and the fewer the horsepower-hours gotten out of it in a year the greater will be the cost of taxes and insurance per horsepower-hour or year.

But there are a couple of other items which are not so well understood. The owner knows that he is paying interest on the cost of the power plant. Perhaps he had to borrow the money with which to build it, in which case the interest cost is as simple as taxes or insurance. If he took the money out of the bank or out of some investment where it was already earning interest for him, his purchase of the steam plant with it deprives him of that interest and puts him in the same position as if he let this remain invested and borrowed new capital at the same rate of interest with which to buy his plant, in which case there would be no question of the interest charge. When the desirability of the plant as an investment is considered, however, this interest which it is earning upon its cost must be taken into consideration. If the owner must borrow the money, the plant must earn six per cent. of its cost for somebody else before it commences to pay him anything. If it is built with his own money it must earn six per cent. before he is any better off than as though he had not built it, but had loaned his money to somebody else.

The most confusing item, however, is depreciation. One can see the coal being used and new coal coming in, and he can tell how much coal he uses per horsepower-hour, but he cannot see his engine being used up. He does not see new engines constantly coming in, and does not stop to think that this engine will last only a certain number of years, and produce in its lifetime a certain number of horsepower-hours, and that for every horsepower-hour which it produces he is using up so much engine, as well as so much coal and oil.

This applies not only to the engine, but to the boiler, the auxiliaries, the chimney, the building, and perhaps, even to the ground.

If a man buys a piece of ground for $5000 and puts a flour mill upon it, and after a while the mill burns down or is moved off and he sells the land for $3000, then every barrel of flour made in the mill must be charged with its quota of that $2000 which the use of the land during the life of the mill cost the owner.

This falling away in value is called "depreciation." In the case of land there may be "appreciation," or rise in value, but in the case of buildings and machinery ruin and the scrap heap are inevitable. It is only a question of time, and that time determines how much of the cost should be charged to the power plant each year.

If one pays $20,000 for an engine and it lasts twenty years, he is using up a thousand dollars' worth of engine a year, and must include this in the power cost or he will fool himself in regard to profit in the long run, although it may look rosy until the need of renewal begins to be apparent.

The way to meet this would appear to be to make the most intelligent estimate possible of the time that the plant will last. Many things may affect this. It may become obsolete while it is still in good condition; that is, there may be something so much better brought out that it would pay to scrap this and put in the more efficient installation. This is called "obsolescence." The plant may become outgrown and will, even if in good condition, bring but a fraction of what it cost installed and ready to run when offered second hand. It may live its life, serve its full time and go to the scrap heap. One must estimate as best he may how long the present outfit will last and when it may be expected to be "all in." But suppose one knew that the engine which cost him $20,000 today would last twenty years; how would he charge it into the yearly expenses? Shall he take out a thousand a year, charge it to the power plant and put in aside so that at the end of twenty years he will have the fund at hand to buy the new engine which will be required? If he does and puts the money out at interest, he will have too much at the end of the twenty years, for he will not only have the principal, enough in itself, but the compound interest on the successive sums. One thousand dollars put away at the end of each year,

at six per cent. compound interest, would accumulate in twenty years to the sum of nearly $37,000, and to accumulate a sum of $20,000 would require an annual deposit of only about $540. This is called "amortization," or the killing off of a debt or charge.

The usual practice is to charge something like five per cent. of the investment per annum for depreciation when computing the over-all cost of horsepower production and kindred problems.

Are You a CO_2 Engineer?

Most engineers are interested in indicator diagrams. This is evident from the large number of cards mailed to POWER each month. The diagrams are usually from two classes of engineers: those who wish to know how to figure the horsepower indicated by the diagrams, and others who have learned how to take them and figure the horsepower, besides making proper valve adjustments. The latter diagrams are not accompanied by a request to tell what there is wrong about them, but are sent more in a spirit of "here they are, better them if you can."

Both kinds of diagrams show that the engineers are taking an interest in their work, and that they realize the importance of knowing how to indicate an engine, set the valve and figure the horsepower developed.

Strange as it may seem, no such interest is taken in the performance of the boiler furnace. It is seldom that a letter is received inquiring about the working of a CO_2 recorder or how better results may be obtained from certain furnace conditions. Engineers cannot be blind to the fact that the great saving to be made in the power plant in the future will be made in the boiler room. What, then, is the reason for this lack of interest?

The old method of throwing coal into the furnace in a haphazard manner is fast passing, and the idea that good combustion is taking place because the ash-pit doors are wide open and the damper regulator operates is fast being dispelled. In fact, such methods of firing belong to the time when tallow was the lubricant for steam-engine cylinders and when hemp rope was used for piston packing. The man who holds to the old ways of doing things is fast becoming a back number.

Are you going to keep on in the same old way? Are you going to allow your firemen to throw in the coal and regulate the draft by guesswork, or do you intend to get on the track of progress and operate your boilers on a new plan?

Why not get as interested in the development of CO_2 gas as in indicating a steam engine? To operate a steam engine properly the diagram is indispensable, and the making of CO_2 is just as important for efficient steam-boiler service.

It would appear that a great many engineers do not realize the importance of flue-gas analysis, for if they did, they would have more to say about the subject. It can hardly be possible that there are very many who do not know about the important gains to be made by the intelligent firing of a boiler and by properly regulating the air and the coal supply. This fact is known to most engineers, but how do they propose to find out when their fires are being operated to the best advantage?

A CO_2 recorder will tell when fuel is being wasted; it will also tell the engineer when he is obtaining the greatest number of heat units from the fuel. It will act as a check on the fireman, and, if properly handled, will indicate just what performance is taking place in the furnace.

Publicity usually means the making or breaking of a new device and its method of operation. If the CO_2 recorder will do what is claimed for it, there must be some engineer who has had interesting experiences with the apparatus, who has found out that by analyzing the flue gases he has made a saving in coal consumption.

An account of such experiences would be of much interest to others and would doubtless assist some in getting started toward operating their boiler plants more economically than they have hitherto.

Myrine

With flaring headlines in type over an inch high, the *Catholic Union and Times* in a recent issue informs the waiting world that "the greatest invention since Edison and Tesla" has been made by Charles H. Myers, of Buffalo, N. Y., who is heralded as "the most wonderful inventor of the century." We do not happen to know how Edison and Tesla rank as inventions—in fact, we did not know they had been invented—they look like human animals of spontaneous growth. Neither do we know how much Mr. Myers paid the *Catholic Union and Times* for printing the foolish statements contained in the article; but whatever the price, it was far too much.

What Mr. Myers has done as the basis of the *Union and Times'* ebullition is to concoct a very ingenious liquid fuel for internal-combustion engines, heating and lighting purposes. Please note that we say "ingenious," not revolutionary or economical. The composition of his fuel Mr. Myers refuses to disclose. He calls it "Myrine" and claims that it is about twice as efficient as gasolene and costs about the same per gallon. The liquid is slightly oily in appearance, evaporates more slowly than gasolene and has an odor reminiscent of benzol. It is poured into what the inventor calls a generator, which appears to be merely a carbureter of the tank type, containing an absorbent material which holds the liquid much as a sponge would. The engine draws air through this generator, which evidently saturates the air with the liquid and makes a too-rich mixture, because an auxiliary air intake at the engine is used.

While "Myrine" is not a "fake" fuel, like Carroll's carbon dioxide, we are strongly of the opinion that its industrial merits are highly exaggerated, whether ignorantly or intentionally we do not pretend to say. The appearance and odor suggest a petroleum distillate somewhere between commercial gasolene and kerosene, but if the statements as to fuel consumption have any foundation whatever in fact, the liquid must have a much higher heat value than gasolene. This leads to the surmise that it may be either dilute picric acid or acetylene gas "dissolved" in acetone or some low-grade ether; if the heat value is not as high as is claimed, the liquid may be a mixture of benzene and denatured alcohol.

A feature of the enterprise that naturally engenders suspicion is that the liquid cannot be bought at any price until the "State rights" are all sold. Mr. Myers' representative told the writer that "Myrine" would be sold to the State companies at fifteen cents a gallon. If it has any such heat energy as is claimed for it, we do not believe that it can be made for anywhere near that price; there is no known volatile hydrocarbon, higher in heat value than gasolene, that can be marketed at such a price, and we decline to believe that Mr. Myers has discovered any new hydrocarbon.

We advise would-be investors to require reliable proof of the heat value in the fuel per dollar of manufacturing cost before putting any money in State rights. In gasolene, one can buy about seven thousand heat units for a cent; if Mr. Myers can sell the consumer a million heat units for a dollar and make money, his scheme is sound; if he cannot, he is simply deluding himself and the purchasers of his State rights.

In order to satisfy some critics who thought that the test of the Manning boiler made at the works of the Bigelow Company last July, and reported in our issue of July 26, was not entirely representative, in view of the fact that the openings for the handholes had not been cut out of the reinforcing plate, the test was repeated on October 25 with such openings cut out and the section of the boiler exactly in the condition in which it is regularly built. The pressure was run up to over 900 pounds, and the boiler failed by collapsing a tube, showing that the barrel, reinforced in the manner under discussion above the staybolts, is by no means the weakest part of the structure and is entirely adequate for the service for which it is built.